ENVIRONMENTAL MONITORING REPORTS

from the

1979 Maine Cooperative Spruce Budworm Suppression Project

Bureau of Forestry

DEPARTMENT OF CONSERVATION
MAINE

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I. SUMMARY OF FINDINGS

The following summary highlights the significant findings of the monitoring effort for the 1979 Budworm Suppression Project. Detailed discussions of these findings can be found in the appropriate sections of the report.

ANALYSIS OF AIRBORNE DRIFT

- Mass deposits at edge-of-block and out-of-block were substantially lower than expected in-block application rates
- Wind is a critical factor. Areas downwind from a spray area will experience higher deposits than cross wind areas.
- Different wind directions and line of flight orientations create varying drift (mass deposit vs. distance) patterns:
  - When wind direction and lines of flight are parallel, mass deposits remain at constant levels for greater distances before decreasing sharply.
  - When wind direction and lines of flight are perpendicular, mass deposits remain constant or decrease slightly, then increase to a peak at varying distances from the edge-of-block before decreasing sharply.
  - Mass deposits over distance decrease rapidly in areas where cross wind and no wind conditions exist.
- Mass deposits recorded beyond 1/4 mile out-of-block were a result of deposition of droplets with diameters of less than 33μm for Dylox and 69μm for Sevin-4-Oil. Deposits recorded at less than 1/4 mile out-of-block had droplets with diameters ranging up to 109μm for Dylox and 262 μm for Sevin-4-Oil.

ANALYSIS OF WATERBORNE DRIFT

- Watershed impact can be expected and is unavoidable. Runoff generated from rainfall will carry pesticides from the watershed into the streams.
- Rainfall and runoff impact on stream concentrations decrease with time as a result of levels of pesticides lowered by natural degradation processes and by previous pesticide runoff removal.

- Dylox appears to be most sensitive to rainfall and runoff when compared with Sevin-4-Oil and Orthene.

- Dylox travels uniformly throughout the stream profile.

- Dylox has an impact on sediment concentration initially, but is removed with time.

- Sevin-4-Oil appears to be more resistent to removal by runoff as evidenced by substantially lower concentrations.

- Because of its carrier (oil), Sevin-4-Oil does not travel as readily throughout the stream profile.

- It is not know whether initial concentrations of pesticides in the streams are due to drift over the buffered area, violations of buffer policy, or both.

- Pesticides do not appear to be deposited in streams when applied by helicopter; however, after application by fixed-wing aircraft, pesticides are found in streams.

ANALYSIS OF PESTICIDE PRESENCE AND PERSISTENCE ON FOLIAGE AND LEAF LITTER

- Pesticide persistence appears to be short lived on foliage and leaf litter due to the chemical properties of the pesticides.

- Rainfall appears to accelerate observed pesticide decomposition and to cause variations in concentrations on leaf litter.

II. INTRODUCTION

ASSIGNMENT

The scope of work conducted under this project consisted primarily of monitoring pesticide drift outside of target areas (blocks designated to be sprayed). In addition, monitoring of pesticide residue and persistence on foliage and leaf litter was included. The specific items in the monitoring effort were:

- Monitoring of airborne drift of pesticide
  - out of the spray blocks
  - ambient air pesticide concentrations at the Presque Isle and Millinocket airports
- Monitoring of waterborne drift of pesticides
- Monitoring of pesticide presence and persistence on foliage and leaf litter.

III. MONITORING PROCEDURES

MONITORING OF AIRBORNE DRIFT

Airborne concentrations of pesticides were monitored to develop information on the travel of pesticide in the air environment at the edges of the target areas and at the working areas at base operational airports. Presumably, the information could be combined with other work to aid in the development of acceptable standards for buffer policy and ambient air standards.

Out-of-Block Drift

Two pesticides, Dylox and Sevin-4-Oil, were monitored at five spray blocks with six sample lines. At each sample line location, the basic arrangement illustrated in Figure 1 was used to collect data. The arrangement consisted of establishing monitoring locations at 1/8-mile intervals from 1/8 mile into the spray block to 1 mile out of the block and at 1/4-mile intervals from 1 mile to 2 miles out of the block. A spray deposit card was placed at each station. To correlate data, glass plates were also placed at selected stations.

The cards and glass plates were placed at the appropriate monitoring stations outside the designated spray blocks. Between one and three hours after spraying was completed, the samples were collected and processed or stored.

Detailed explanations of the field procedures can be found in USDA Technical Bulletin 1596 (1).

Block Location --

Five spray blocks were monitored for out-of-block, airborne drift. The pesticides used and sample line designations for each block were:

- Dylox - block 30-5 - lines A & B
- Sevin-4-Oil - blocks 13-10, 14-1, 9-8, and 14-6 - lines C, D, F, and G.

Figures 2 through 6 depict the sample line locations for each block. In addition, the wind direction, flight direction, and foliage sample locations are noted.

Monitoring Procedures --

Monitoring procedures were derived primarily from USDA Technical Bulletin 1596. This provides for a level of standardization with past and future sampling programs. The procedures were tailored, however, to meet the needs of the monitoring program as described in the Bureau of Forestry's Request for Proposals.

		Edge of Block	←	—	—	1/8 mile intervals	—	—	→ 1 mile	←	¼ mile intervals	→	2 miles	
Station #	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Spray Deposit Cards	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Glass Plates		X		X		X		X		X		X		X
Meteorological Equipment				X										

Location of glass plates, high volume air sampler and meteorological equipment varied for each line, but this illustration is generally representative of a typical line.

FIGURE 1.
TYPICAL SAMPLE LINE LAYOUT

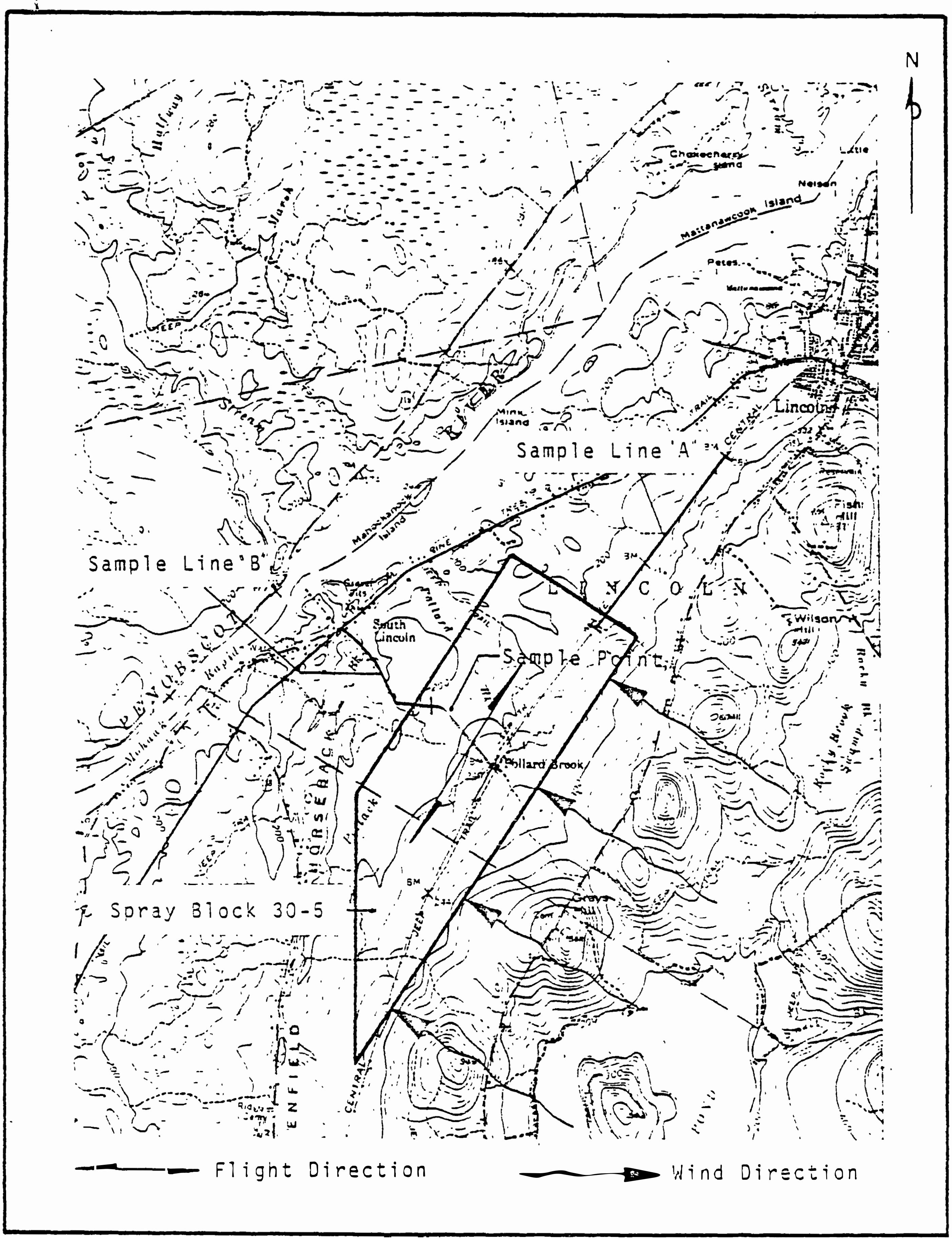


FIGURE 2. SPRAY BLOCK: 30-5
SAMPLE LINE A AND B
FOLIAGE AND LEAF LITTER SAMPLE SITE
DYLOX

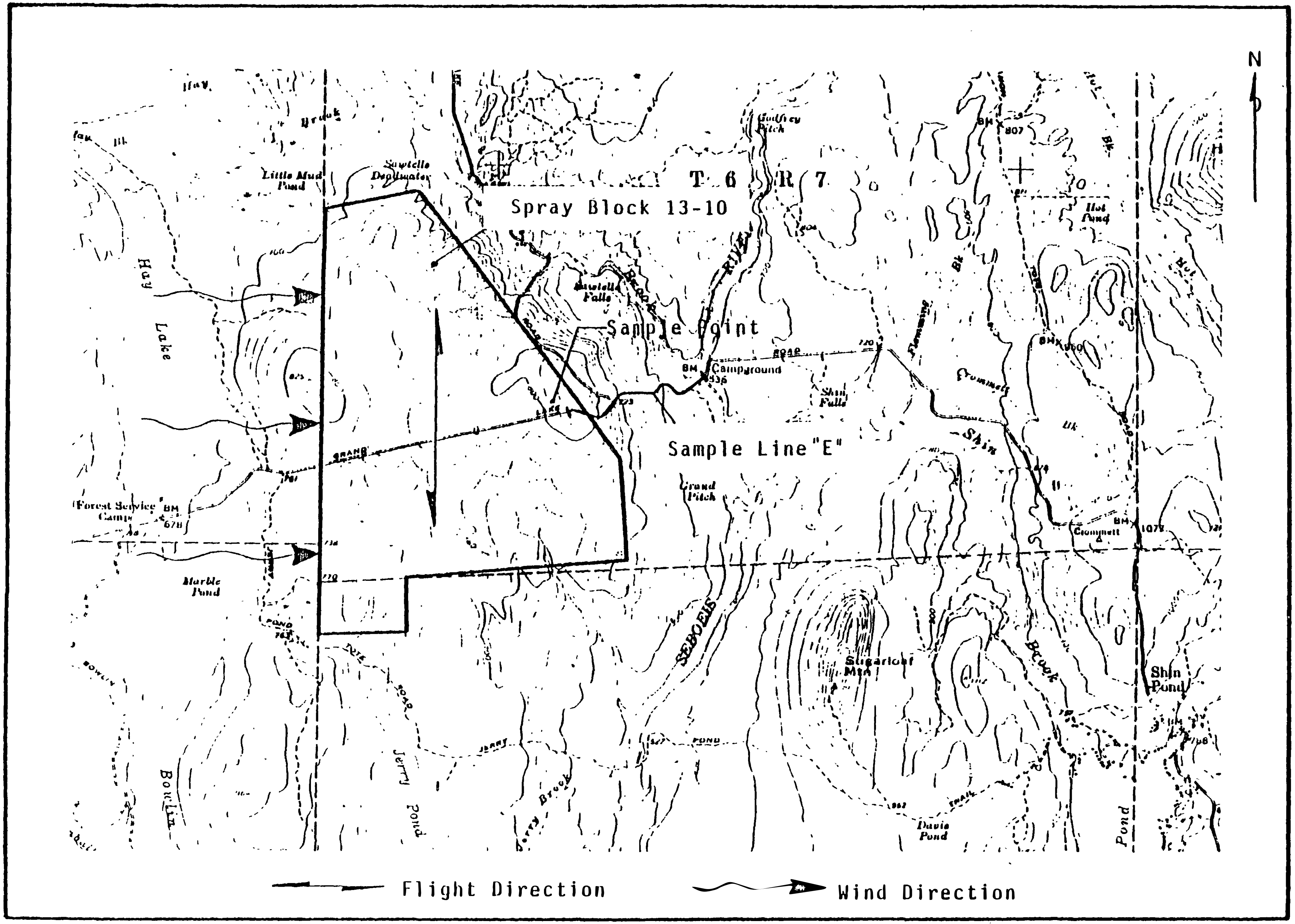


FIGURE 3. SPRAY BLOCK: 13-10
SAMPLE LINE E
[illegible]

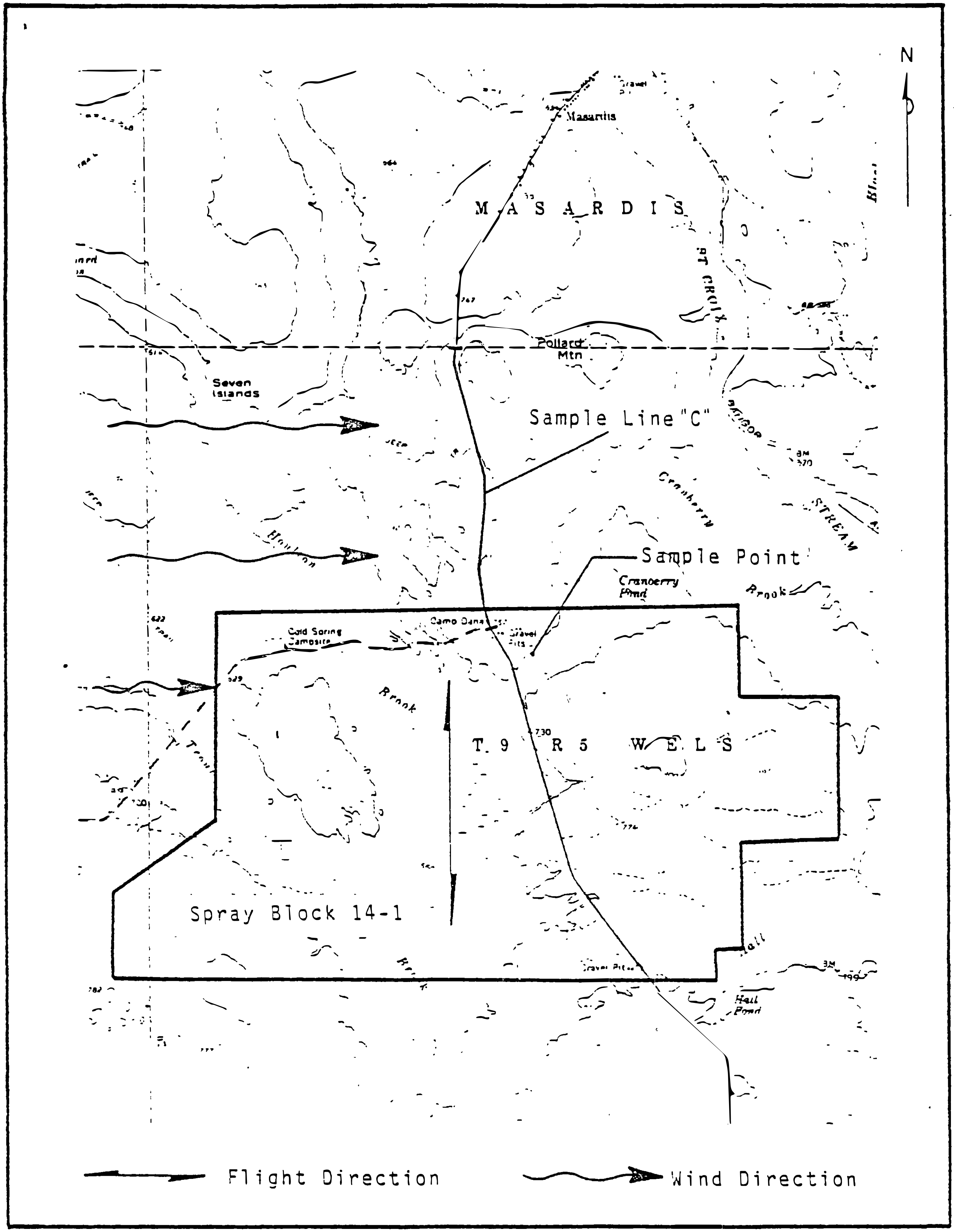


FIGURE 4. SPRAY BLOCK: 14-1
SAMPLE LINE C
FOLIAGE AND LEAF LITTER SAMPLE SITE
SEVIN-4-OIL

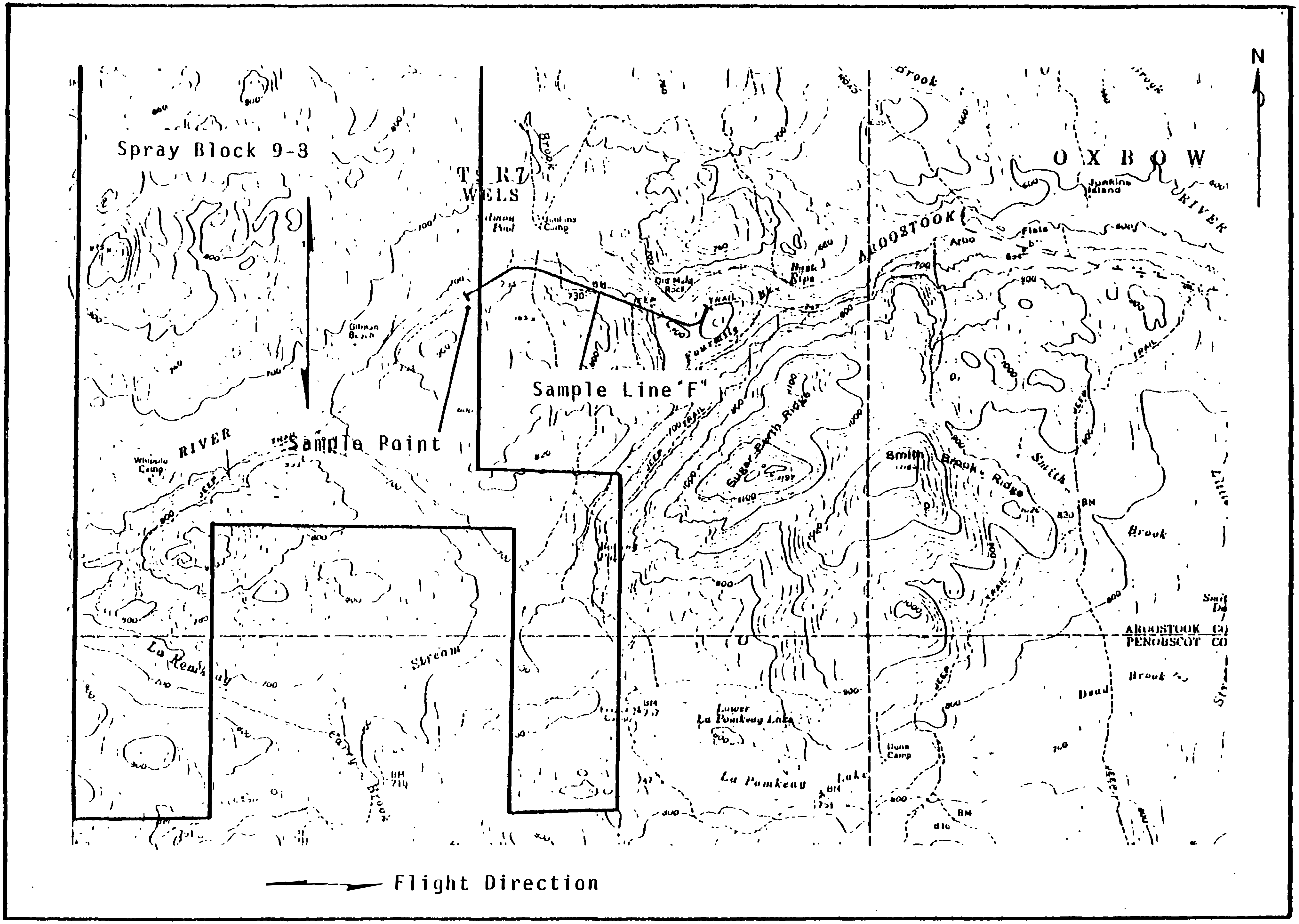


FIGURE 5.
SAMPLE LINE F

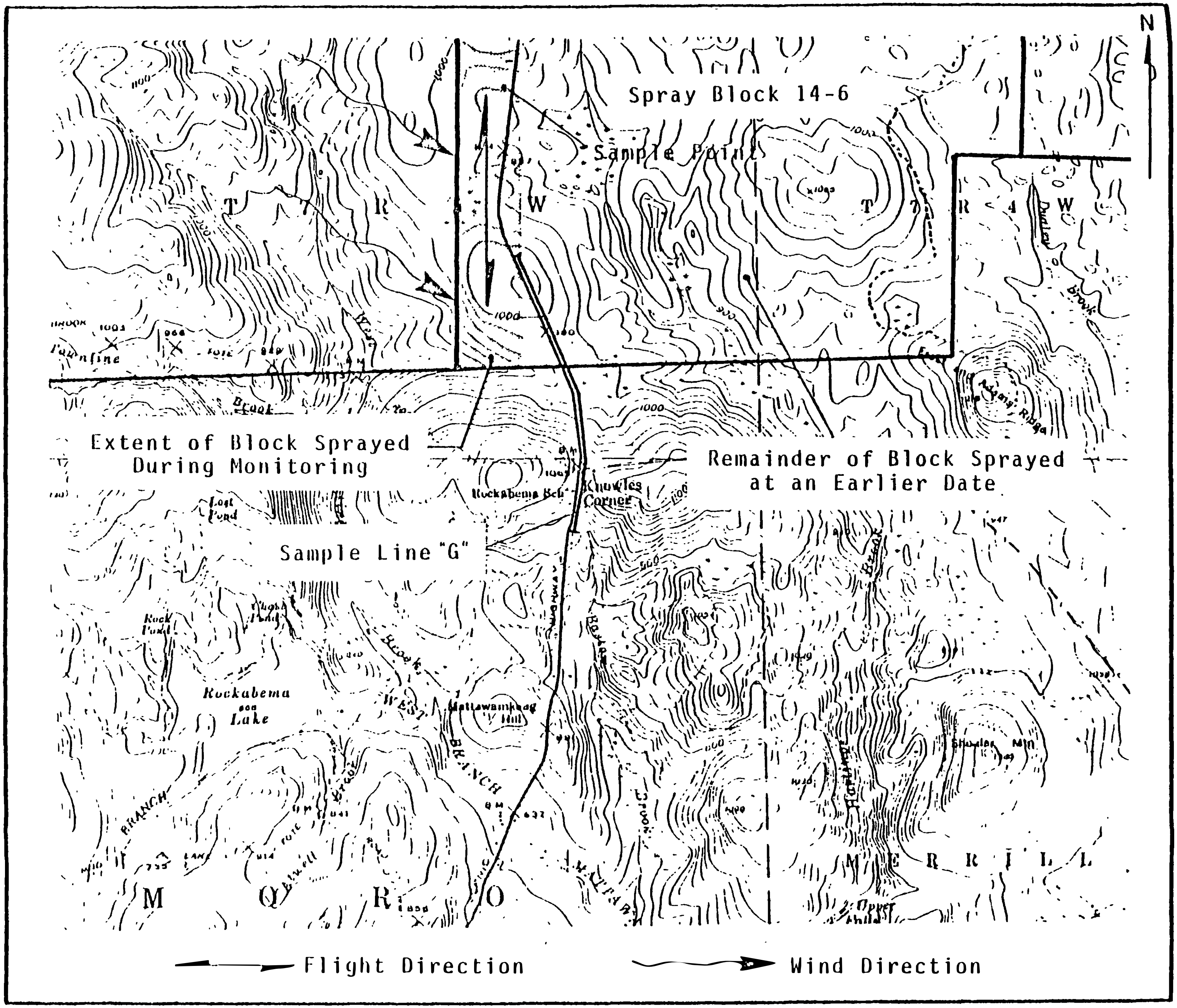


FIGURE 6.
SAMPLE LINE G
FOLIAGE AND LEAF LITTER SAMPLE SITE
SEVIN 4 OIL

Spray deposit cards and plates were laid out in the prescribed fashion along the sample lines, located as shown in Figures 2 through 6, prior to the block being sprayed. They remained in position until one to three hours following the application of the pesticide in the block. The spray deposit cards were then removed and placed in specially made card holders where they were stored until they were analyzed. The glass plates were collected individually. Each was rinsed with a solution of methylene chloride. The solution which contained the pesticide was directed into glass jars which were sealed.

<u>Airport Sampling</u>

During the spraying operation, the hi-vol air samplers were continuously operated, by the state, at the Millinocket and Presque Isle airports.

The sampler at the Millinocket airport was located adjacent to the headquarters building. This was about 1,000 feet away from the loading area which was further down the runway. The location of the sampler near the headquarters building avoids the weighted results that might occur if the sampler were located within the central loading area. Instead, pesticide readings actually are a result of drift out of the mixing area.

In contrast to Millinocket, the Presque Isle air sampler was located near an outbuilding adjacent to the loading apron. While not directly within a loading or mixing area, it was more sensitive to drift from the loading operations. The sampler was located about 75 yards downwind of the loading stations and a similar distance upwind of the insecticide mixing area. The area where the sampler was located was utilized by operational personnel.

Schedule --

The air samplers were operated over 24-hour intervals during and after spraying at each airport. Pre-spray samples were not available due to the lack of time between contract award and spray commencement. Samplers were started during the mixing and loading procedures and continued in operation until after the corresponding spray period on the next day.

Four consecutive 24-hour sample sets were taken at Millinocket airport. The series was started on the evening of June 1 and continued until the evening of June 5, 1979.

At Presque Isle airport, three 24-hour sample sets were taken. They were dated June 2 through 3, June 5 through 6 and June 9 through 10, 1979. The sampling at Presque Isle commenced at approximately 8:00 p.m. for each of the periods.

Sampling Procedures --

The operation of the hi-vol air samplers allowed large volumes of air to pass through an ethylene glycol solution. The pesticides contained in the air were trapped by the solution.

To provide suitable control, the ethylene glycol was changed at the end of each 12-hour period. The removed ethylene glycol was transferred to 8-oz. jars and labelled for proper identification and stored on dry ice.

A measure of the amount of air collected and the amount of pesticide trapped enabled determination of the concentrations in the ambient air.

MONITORING OF WATERBORNE DRIFT

Concentrations of waterborne pesticides were monitored to determine the effectiveness of the buffer policy and the impact of rainfall. Three pesticides, Orthene, Dylox, and Sevin-4-Oil, were monitored in three water courses.

- Orthene - block 22-4 - Alder Stream and North Branch of Dead River
- Dylox - block 30-4 - Mattamiscontis Stream and Ayers Stream
- Sevin-4-Oil - block 9-6 - North Branch of Presque Isle Stream

The blocks and associated streams are illustrated in Figures 7 through 9.

Sampling Scheme

All sample streams were sampled one to five days prior to spraying to provide control data. Each stream was then sampled in accordance with the schedule illustrated in the following matrix:

SAMPLING SCHEME

Item	Days Pre-Spray	Days Post-Spray			
	6-3	1st day		2	6
		1 hr	24 hr		
2 samples, surface film	X	X	X	X	X
2 samples, mid-depth	X	X	X	X	X
2 samples, stream bed organic matter	X	X			X

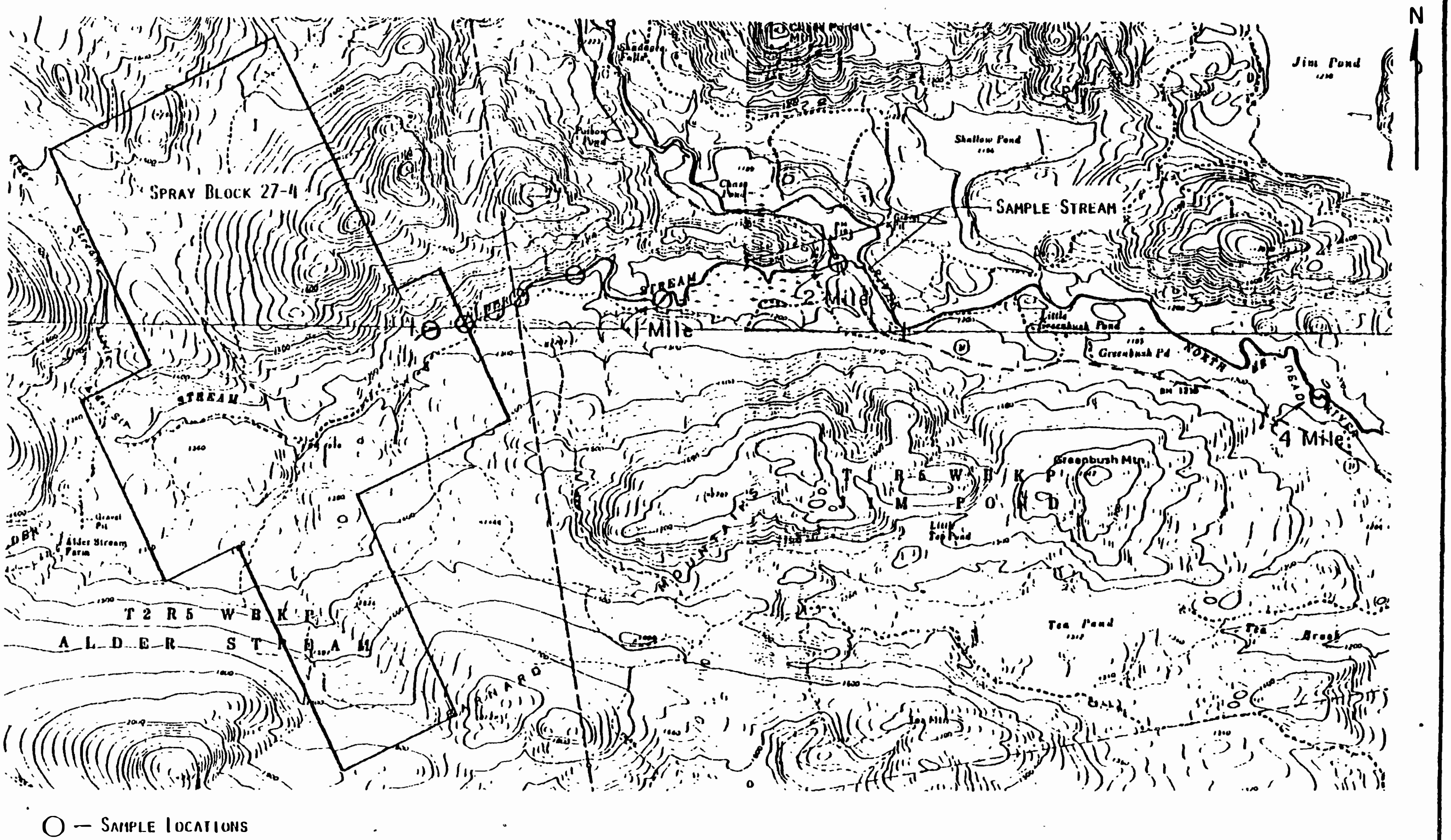


FIGURE 7. SAMPLE LOCATIONS ON ALDER STREAM AND NORTH BRANCH
DEAD RIVER - SPRAY BLOCK 27-4
ORTHENE

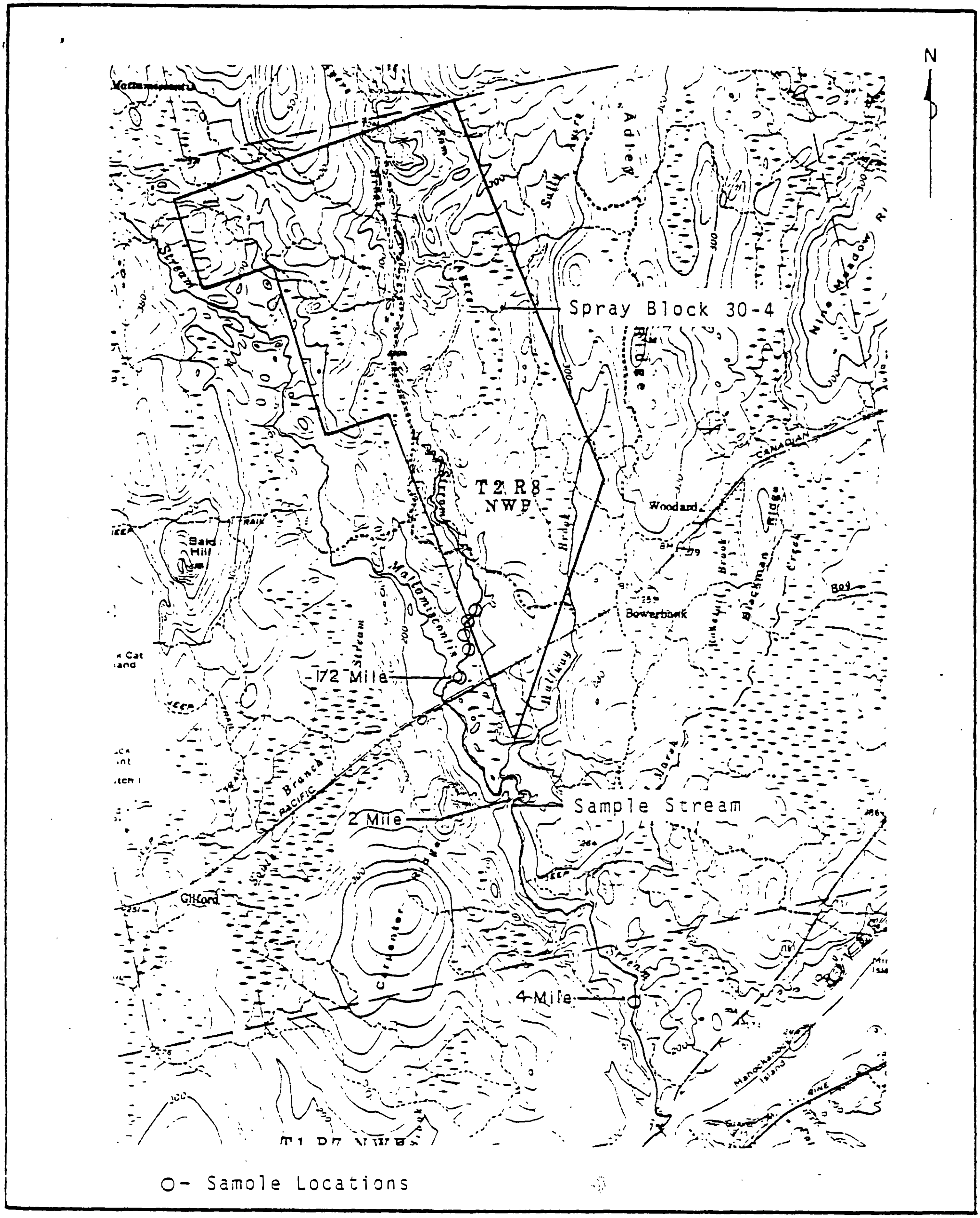


FIGURE 8. SAMPLE LOCATIONS ON AYERS AND MATTAMISCONTIS STREAMS - SPRAY BLOCK 30-4 DYLOX

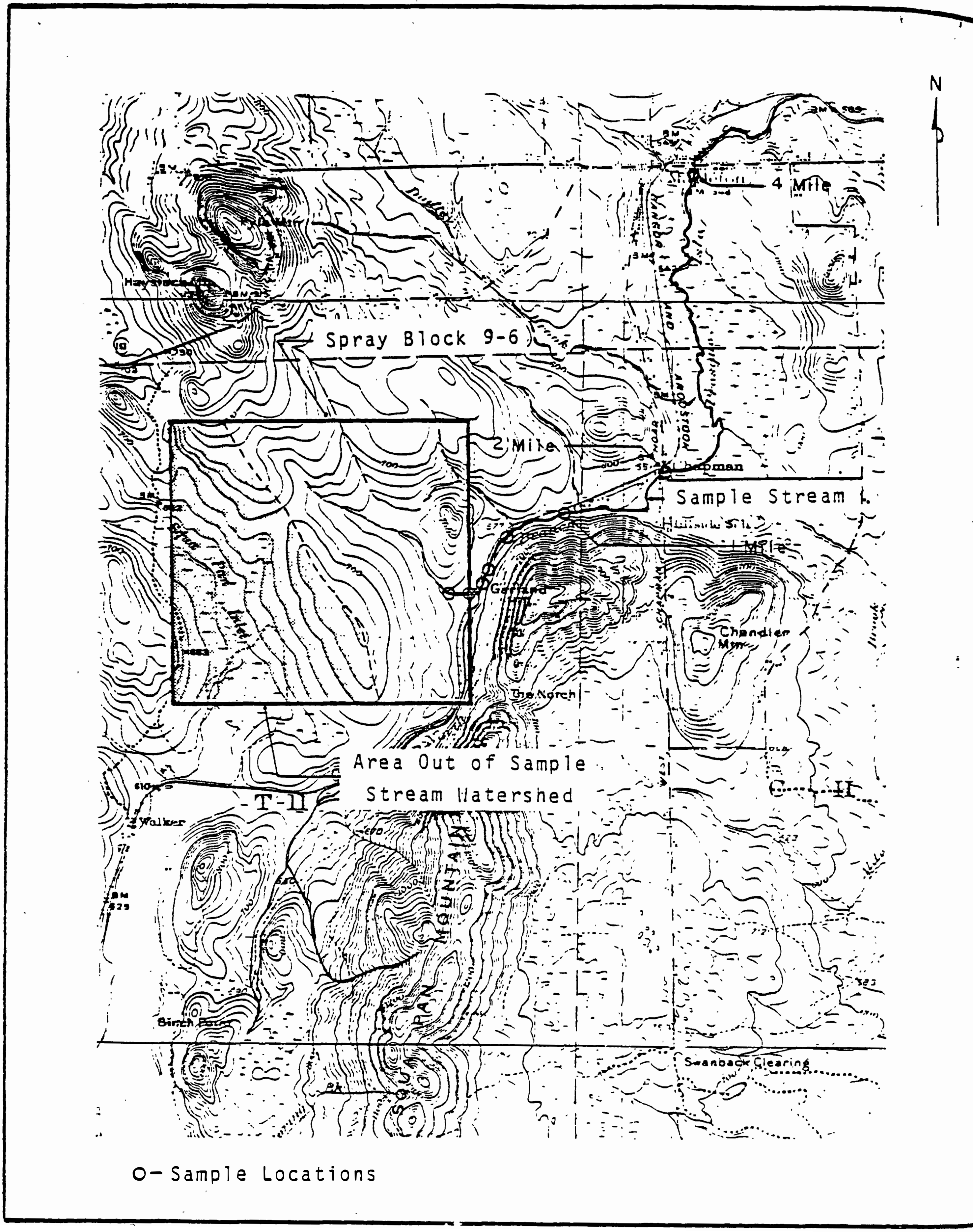


FIGURE 9. SAMPLE LOCATIONS ON NORTH BRANCH PRESQUE ISLE STREAM - SPRAY BLOCK 9-6 SEVIN-4-OIL

Sampling was performed at eight points along each stream; (1) in the spray block, (2) at the edge of the spray block, (3) 1/8 mile downstream, (4) 1/4 mile, (5) 1/2 mile, (6) 1 mile, (7) 2 miles, and (8) 4 miles downstream.

Water Sampling

Water samples at each location were obtained by grab samples. Samples were taken at the surface and at mid-depth, preferably as close to the center of the channel as was possible. Samples were stored in new ½-gallon bottles and were acidfied to a pH of 2 or 3 with 1 molar hydrochloric acid (HCl). Acidity was determined by using colormetric comparison. The samples were put in dry ice as soon as feasible and then transfered to a freezer. These procedures minimized pesticide degradation, thus ensuring accurate results.

Associated data were collected at each point. In particular, the daily precipitation was recorded at the beginning of each stream sample line.

Sediment Sampling

Sediment samples were gathered at each station where water samples were taken. Grab samples were obtained within the top ½ inch of sediment and were placed in Zip-Loc bags. Samples consisted of approximately 1 lb of material. All samples were stored in freezers until the Public Health Laboratory analyzed them.

MONITORING OF PESTICIDE PRESENCE AND PERSISTENCE ON FOLIAGE AND LEAF LITTER

Pesticide concentrations on foliage and leaf litter were monitored to: (1) establish a relationship between the application rate and the concentrations on the foliage, and (2) to determine the persistence of the pesticide in the foliage environment. In order to accomplish these objectives, foliage and leaf litter samples were obtained in the same spray blocks monitored for out-of-block drift. The sample points were located as close as possible to the in-block sampling points.

Schedule

The schedule used to obtain foliage and leaf litter samples is summarized in Table 1.

Sampling Techniques

Pre-spray and post-spray samples of both foliage and leaf litter were taken in each of the spray blocks which were monitored for out-of-block pesticide drift.

Foliage samples were taken at mid-crown height. (Figure 10) The preferred sampling species was Balsam fir (*Abies balsamea*) since it is the preferred host of the budworm. Spruce (*Picea*

TABLE 1. SCHEDULE FOR FOLIAGE AND LEAF LITTER SAMPLING

Spray Type	Thrush Dylox		TBM Sevin		C-54 Sevin		C-54 Sevin		C-54 Sevin	
Block	30-5		13-10		14-1		9-8		14-6	
Approximate Sample Day	Sample Date	Sample Day	Sample Date	Sample Day	Sample Date	Sample Day	Sample Date	Sample Day	Sample Date	Sample Day
1	5/28	1	6/7	1	6/7	1	6/7	1	6/14	1
7	6/4	8	6/14	8	6/14	8	6/14	8	6/21	7
14	6/11	15	6/21	15	6/21	15	6/21	15	6/28	15
30	6/28	33	7/10	34	7/10	34	7/10	34	7/10	27
60	7/26	60	8/9	64	8/9	64	8/9	64	8/9	57
90	8/27	92	9/5	91	9/5	91	9/5	91	9/12	91

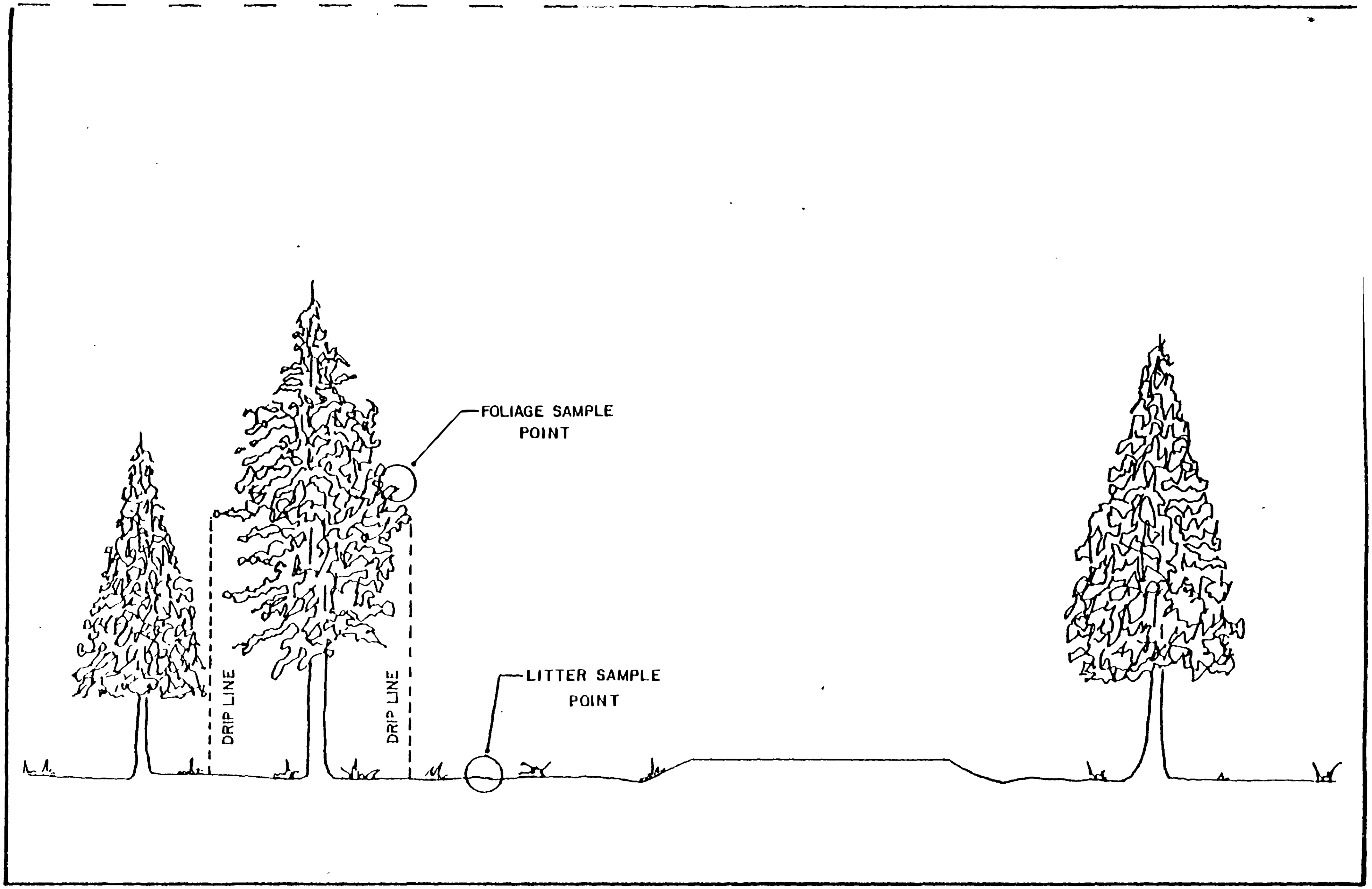


FIGURE 10. TYPICAL SAMPLE SITE

spp.) and hemlock (*Tsuga canadensis*) were the second and third choices of sample species. Individual samples were obtained by use of pole pruners and consisted of branch tips approximately 10 inches long. The branches were taken from several points on each tree. As foliage samples were taken, a composite of the twigs and needles was placed in Zip-Loc bags and sealed. The sample bags were labeled and stored in dry ice chests for transportation to storage freezers.

The forest floor leaf litter was obtained in the same area as the foliage samples. Care was taken to ensure that the samples were taken in areas outside of the drip line of the tree. (Figure 10). Approximately one pound of surface litter (less than ½ inch in depth) was taken from each location and placed in Zip-Loc bags for labeling and dry ice storage prior to being placed in storage freezers.

IV. ANALYSIS OF AIRBORNE PESTICIDE DRIFT

OUT-OF-BLOCK PESTICIDE DRIFT

Out-of-block pesticide drift data were obtained by means of spray deposit cards and glass plates.

Spray Deposit Cards

Spray deposit cards were analyzed in a three-step process.

Preparation of the Spray Cards --

The spray deposit cards (KROMEKOTE) were used at all sampling stations. Before the cards were analyzed, they were examined for obvious abnormalities. Cards that were smeared or affected by moisture and/or accumulation of foreign material were not used. A permanent grid was scribed onto the card surface by means of a fine-pointed instrument. This procedure permanently recorded the sample areas and reduced the possibility of a template causing damage to the card surface. Each card was scribed in a manner similar to that shown in Figure 11.

Analyzing Spray Cards --

A Bausch & Lomb stereo microscope, fitted with 10X eyepieces and a zoom-type objective lens with a range of 0.7X to 3X, was used to count the number of stains. An eyepiece reticle, with a grid system incremented in fractions of an inch, was used to determine the size of the stains.

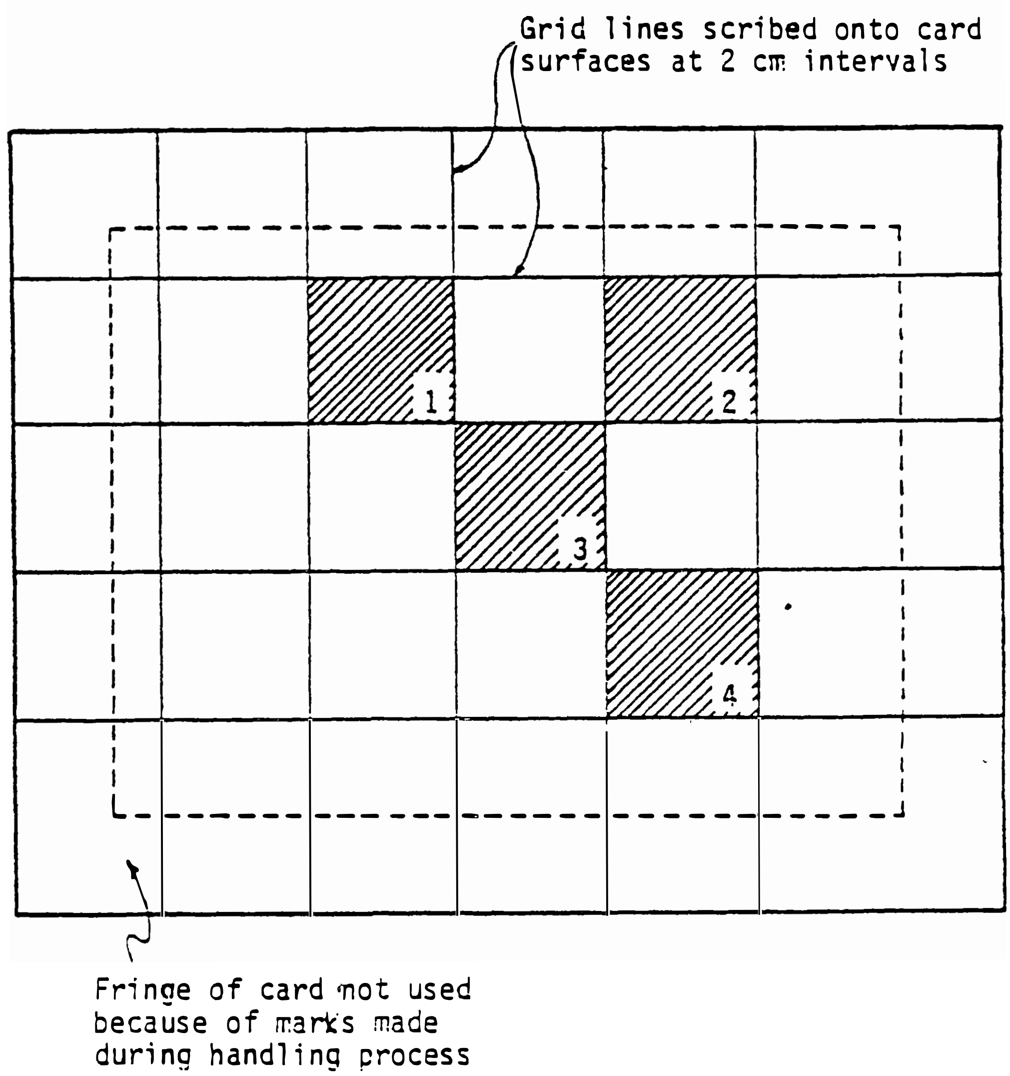
To determine the mass deposit, the number of stains (droplets) had to be counted by size categories. The categories shown in Table 2 were considered appropriate for the range in stain sizes observed. In addition, the stain size categories were distinguished by using the reticle grid which was visually subdivided into the categories.

Conversion of Data --

The stain density data developed above was summarized for each sample line (Table 3). For each location along each sample line, mass deposit and droplet density calculations were performed. To do this, the stain data were converted to droplet data using regression analysis calculations from USDA Technical Bulletin 1596 (See Appendix A). Using the format shown in Table 3, mean droplet diameters were determined for each size category. Mean droplet mass was then calculated, followed by calculation of density and deposition.

Glass Plates

The glass plates were processed in the field. The plates were placed on a laboratory stand and washed, using a pesticide grade methylene chloride. The wash was collected in a funnel and emptied into glass jars. The samples were then placed on dry ice until they were stored in a freezer.



Shaded blocks represent the pattern of blocks analyzed on each card.

FIGURE 11.

TYPICAL SPRAY CARD PREPARATION

TABLE 2. TYPICAL SPRAY CARD ANALYSIS SHEET

B-LINE - DYLOX

Card #	<.0025	.0025-.005	.005-.0075	.0075-.01	.01-.0125	.0125-.015	.015-.0175	.0175-.02	>.02	
B-1	1	8	20	29	14	9	3	3	3	1-8-20-29-14-9-3-3
B-2	6	14	20	12	6	1	0	1		6-14-20-12-6-1-0
B-3	3	9	5							3-9-5
B-4										

TABLE 3. TYPICAL DROPLET SPECTRUM ANALYSIS CALCULATION.

Test 9 Row/Line C Spray material DYLOX Material density 1.067 (g cm^{-3})

Analyst: John Doe Stain factors: a = 7.68, b = 0.199, c = 5.73x10^{-6}

		Size category											
		1	2	3	4	5	6	7	8	9	10	11	12	Total
Stain upper limit (µm)		100	200	300	400	500	600	800	1000	1200	1400	1600		
Stain lower limit (µm)		50	100	200	300	400	500	600	800	1000	1200	1400		
Drop upper limit (µm)		27.6	47.7	67.9	88.2	109	129	171	212	255	298	341		
Drop lower limit (µm)		17.6	27.6	47.7	67.9	88.2	109	129	171	212	255	298		
CARD NO. 43 TEMPLATE AREA 16 cm^2	NUMBER OF DROPS	41	118	121	85	85	40	45	7	2	1	0		545
	DROP DENSITY (drops cm^{-2})	2.562	7.375	7.562	5.312	5.312	2.500	2.812	0.4375	0.1250	0.0625	0		34.06
CARD NO. 46 TEMPLATE AREA 8 cm^2	NUMBER OF DROPS	44	83	54	21	21	11	5	3	1	0	0		243
	DROP DENSITY (drops cm^{-2})	5.500	10.380	6.750	2.625	2.625	1.375	0.6250	0.3750	0.1250	0	0		30.38
CARD NO. 50 TEMPLATE AREA 8 cm^2	NUMBER OF DROPS	69	91	60	24	14	5	2	1	0	0	1		267
	DROP DENSITY (drops cm^{-2})	8.625	11.38	7.500	3.000	1.750	0.6250	0.2500	0.1250	0	0	0.1250		33.38
CARD NO. 54 TEMPLATE AREA 8 cm^2	NUMBER OF DROPS	44	105	84	35	25	19	5	1	0	0	0		318
	DROP DENSITY (drops cm^{-2})	5.500	13.12	10.50	4.375	3.125	2.375	0.6250	0.1250	0	0	0		39.74
CARD NO. 57 TEMPLATE AREA 8 cm^2	NUMBER OF DROPS	8	21	36	26	43	39	20	9	3	0	0		205
	DROP DENSITY (drops cm^{-2})	1.000	2.625	4.500	3.250	5.375	4.875	2.500	1.125	0.375	0	0		25.625
CARD NO. TEMPLATE AREA cm^2	NUMBER OF DROPS													
	DROP DENSITY (drops cm^{-2}													
A	Mean drop diameter (µm)	23.0	38.5	58.4	78.5	99.0	119.3	151.0	192.2	234.2	277.1	320.0		
B	Mean drop mass (mg)	6.796 x10^{-6}	3.188 x10^{-5}	1.113 x10^{-4}	2.703 x10^{-4}	5.421 x10^{-4}	9.486 x10^{-4}	1.924 x10^{-3}	3.967 x10^{-3}	7.117 x10^{-3}	1.139 x10^{-2}	1.331 x10^{-2}		
C	Sum of drop densities by size category	23.19	44.38	36.81	18.56	18.19	11.75	6.812	2.188	0.625	0.0625	0.125		
D	Average drop densities by size category (drops cm^{-2})	4.638	8.976	7.362	3.712	3.637	2.350	1.362	0.4375	0.1250	0.00125	0.025		
E	Cumulative drop densities	4.638	13.61	20.98	24.69	28.33	30.68	32.04	32.48	32.60	32.61	32.64		32.64
F	Cumulative percent of drop densities	14.21	41.70	64.28	75.65	86.30	94.00	98.17	99.52	99.88	99.91	100		
G	Average deposition by size category (mg cm^{-2})	3.152 x10^{-5}	2.862 x10^{-4}	8.194 x10^{-4}	1.003 x10^{-3}	1.972 x10^{-3}	2.229 x10^{-3}	2.620 x10^{-3}	1.736 x10^{-3}	8.971 x10^{-4}	1.486 x10^{-5}	4.518 x10^{-4}		
H	Cumulative mass (mg)	3.152 x10^{-5}	3.177 x10^{-4}	1.137 x10^{-3}	2.140 x10^{-3}	4.112 x10^{-3}	6.341 x10^{-3}	8.961 x10^{-3}	1.070 x10^{-2}	1.159 x10^{-2}	1.161 x10^{-2}	1.207 x10^{-2}		1.207 x10^{-2}
I	Cumulative percent of mass	0.26	2.63	9.42	17.73	34.04	52.55	74.26	88.67	96.05	96.21	100		

The samples were analyzed by the Maine Public Health Laboratory using appropriate analytical procedures. The results of the analyses were transmitted to SCS for interpretation of the findings.

RESULTS

The results of the analyses of both the spray cards and glass plates were divided into two topics. The first topic is mass deposit and the second, droplet spectrum.

Mass Deposit

Mass deposit is defined as the amount (weight) of pesticide applied to a unit area. Dylox was applied at a rate of 24 oz/acre. Of this total amount, 9.36 oz/acre was the active ingredient. Expressed in other units, this application rate would be 6.54×10^{-3} mg/cm^2.

The mass deposits calculated for each spray deposit card and analyzed for each glass plate are shown in Table 4. The results are discussed individually for each spray line.

Note that mass deposits on the glass plates for lines B, C, E, and F are consistently lower than those on the pertinent spray cards. Possible explanations for this difference include:

- Interference by the material on the inside of the caps of the sample-containing jars (cap liners were supposed to be Teflon),

- Evaporation through faulty sample container jar seals,

- Differences in the degrees of precision between the two monitoring parameters.

Line "A" --

This sample line monitored the pesticide drift from spray block 30-5 in the Lincoln area. The pesticide, Dylox, was applied by Thrush aircraft to this block. Wind direction was perpendicular to the line of flight. The sample line was cross-wind and parallel to the lines of flight (Figure 2, page 6).

A graph of the results, contained in Table 4, is shown in Figure 12. The mass deposit on the spray card in-block was 8.70×10^{-4} mg/cm^2, which is approximately 13 percent of the full application rate. The spray card at the edge-of-block was discounted as an anomaly. The mass deposit dropped slightly at the 1/8-mile (660 ft) station. The mass deposit then decreased sharply. Glass plate data provided lower concentrations at the first two sampling stations and a substantially higher value at the 5/8 mile station. This high value was discounted because it did not agree with Cramer's model (2). The high

	LINE		LOCATION													
			In Block	Edge Block	1/8	1/4	3/8	1/2	5/8	3/4	7/8	1	1-1/4	1-1/2	1-3/4	2
DYLOX	"A" 30-5	SPRAY CARDS / GLASS PLATES	8.70×10^{-4}	2.52×10^{-4} / 5.81×10^{-4}	6.88×10^{-4} / 9.70×10^{-6}	9.00×10^{-9}	*	*	* / 1.83×10^{-3}	*	* / 1.70×10^{-6}	*	* / 9.00×10^{-7}	*	* / *	*
DYLOX	"B" 30-5	SPRAY CARDS / GLASS PLATES	8.65×10^{-4} / 1.74×10^{-3}	2.34×10^{-4} / 2.38×10^{-4}	1.97×10^{-5}	1.56×10^{-5}	1.74×10^{-5}		3.43×10^{-5}	3.95×10^{-5} / 3.61×10^{-5}	7.69×10^{-5}	-	-	-	-	-
SEVIN - 4 OIL	"C" 14-1	SPRAY CARDS / GLASS PLATES	1.81×10^{-4} / 5.49×10^{-5}	1.23×10^{-3} / 8.80×10^{-5}	2.98×10^{-3} / 2.28×10^{-4}		7.03×10^{-6} / 5.80×10^{-6}	3.44×10^{-5}		2.04×10^{-5} / *		1.21×10^{-5} / *		1.14×10^{-5} / *		9.56×10^{-6} / *
SEVIN - 4 OIL	"E" 13-10	SPRAY CARDS / GLASS PLATES	2.11×10^{-3} / 2.99×10^{-4}	6.40×10^{-5} / 4.05×10^{-5}	1.07×10^{-4} / 3.49×10^{-5}		2.62×10^{-5} / 2.01×10^{-5}		7.65×10^{-6} / *	-	-	-	-	-	-	-
SEVIN - 4 OIL	"F" 9-8	SPRAY CARDS / GLASS PLATES	1.20×10^{-2} / 5.67×10^{-4}	1.03×10^{-3} / 5.1×10^{-4}		2.70×10^{-6}		4.46×10^{-6} / 6.00×10^{-7}		5.74×10^{-6} / 1.20×10^{-6}		4.46×10^{-6} / 3.60×10^{-6}		3.83×10^{-6} / 1.50×10^{-6}		5.10×10^{-6} / 8.00×10^{-7}
SEVIN - 4 OIL	"G" 14-6	SPRAY CARDS / GLASS PLATES	7.79×10^{-4} / 1.40×10^{-4}	5.71×10^{-5}		5.89×10^{-5}		4.65×10^{-5} / 9.00×10^{-6}		6.20×10^{-5} / 4.63×10^{-5}		8.61×10^{-5}		5.17×10^{-5} / 1.27×10^{-5}		1.46×10^{-5} / *

* No Data Obtained
\- Station Not Set Up

1×10^{-2} mg/cm^2 = 14.3 oz/acre (A.I.)
1×10^{-3} mg/cm^2 = 1.4 oz/acre (A.I.)

TABLE 4. MASS DEPOSITS IN MG/CM^2

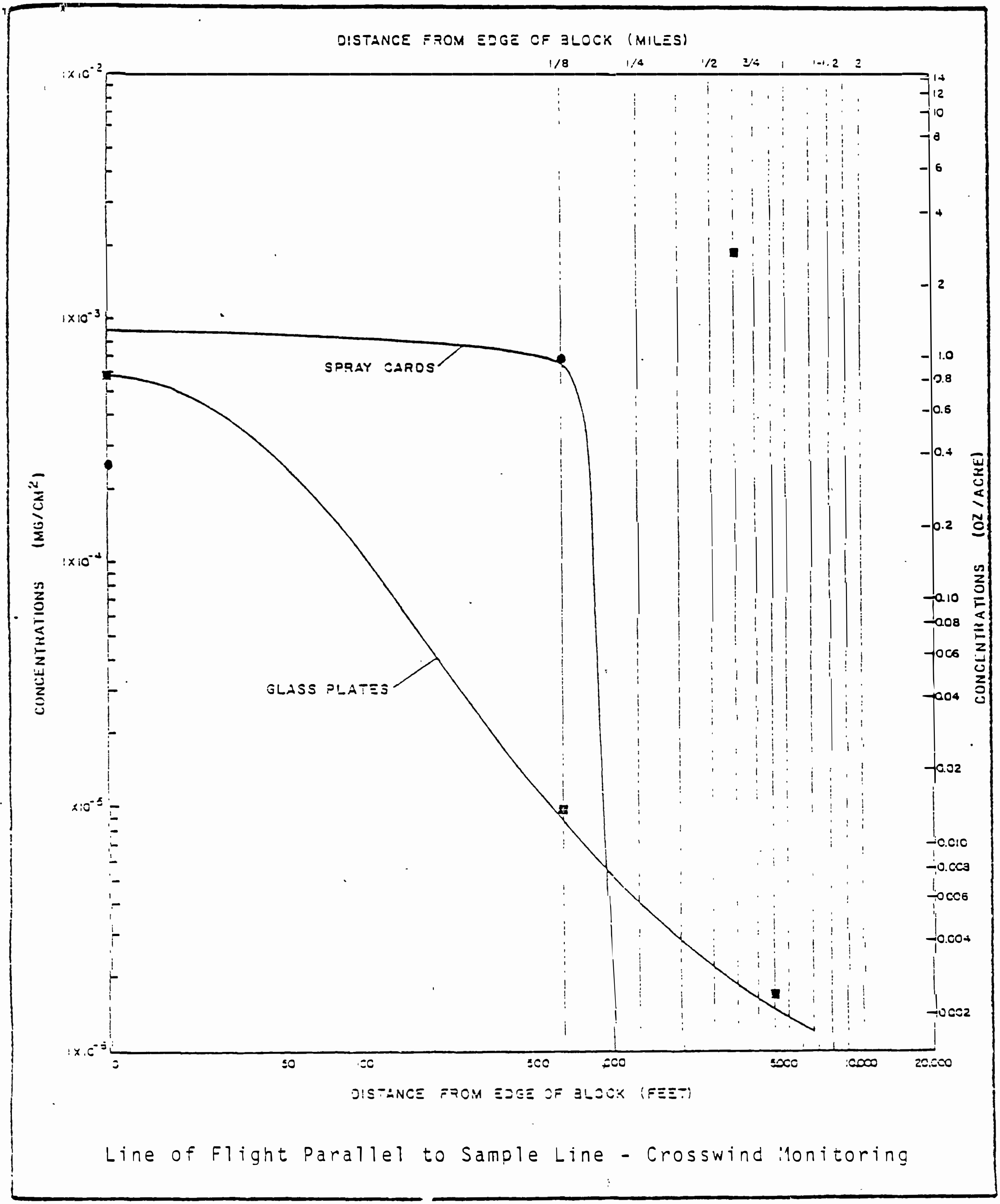


FIGURE 12. $\frac{\text{"A" LINE}}{30-5}$

MASS DEPOSIT AS A FUNCTION OF DISTANCE FROM THE EDGE OF SPRAY BLOCK.

concentration may have been due to a random deposit where the planes made a turn across the spray line during the application.

The graph for this sample agrees with the model developed by Cramer for a cross wind sampling of pesticide applied parallel to the sample line. The steepness of the spray card curve is assumed to be due to the location of the sample line with respect to the edge of the block (Figure 12).

Line "B" --

This sample line also monitored the spray block 30-5 as Line "A". However, this sample line was located 90° counter-clockwise from Line "A" (Figure 2, page 6). Therefore, the sample line was <u>downwind</u> and <u>perpendicular</u> to the line of flight.

The plots of the mass deposit tabulated in Table 4 yielded the curve illustrated in Figure 13. The mass deposits at the edge of the block represent 3.7 percent of the mass deposit for the full application rate. The mass deposit decreased uniformly for a distance of 1/4 mile out-of-block. The mass deposits at this location were 7.9 percent of the mass deposits at the edge of the block and 0.27 percent of the values expected in-block.

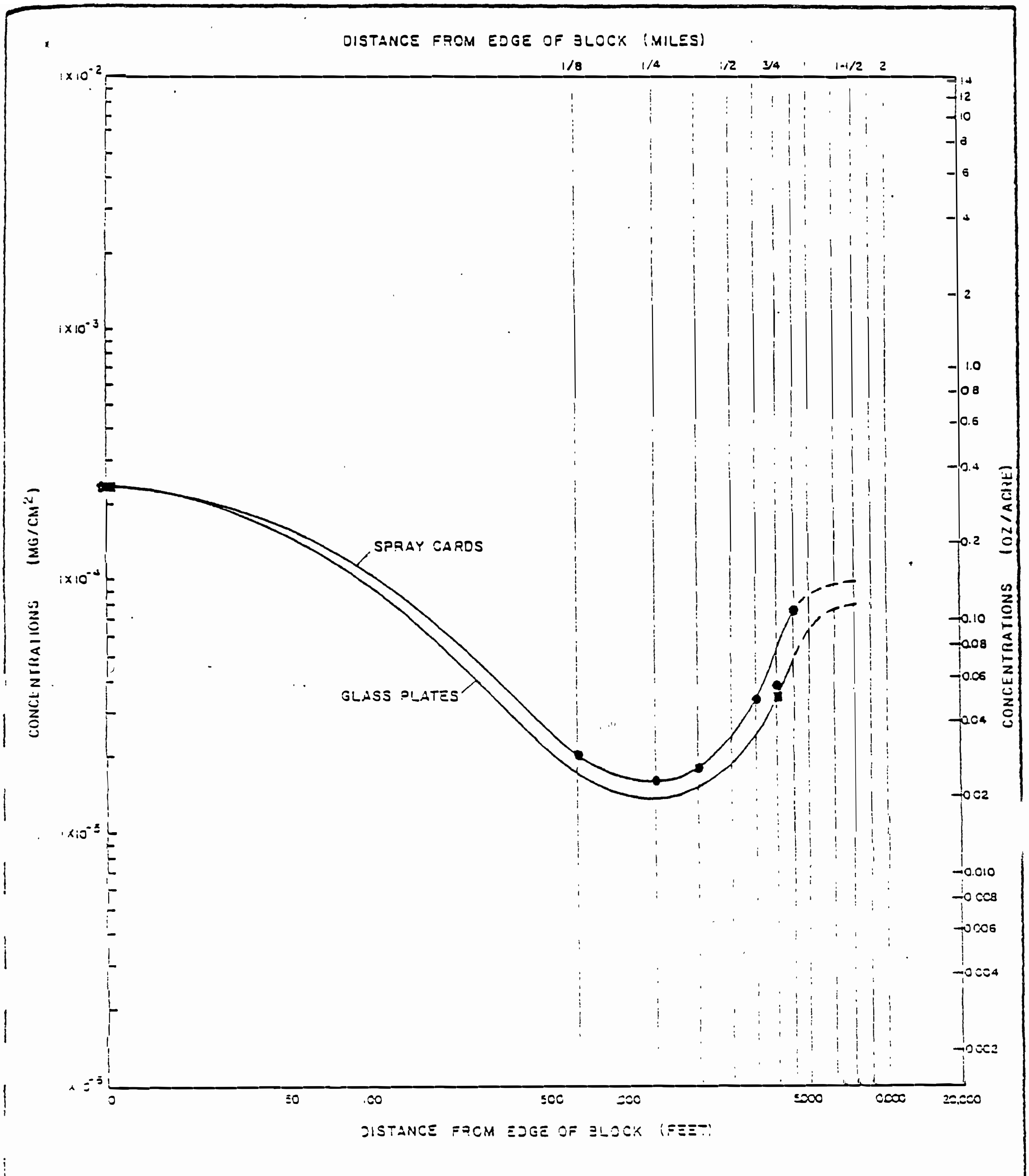
Beyond the 1/4-mile station, the mass deposits increased to a projected peak at about 1-3/4 miles out-of-block. The mass deposit at this location was approximately 40 percent of the deposit registered at the edge of the block. The increase in concentration agrees (with qualifications) with Cramer's model for downwind drift applied perpendicular to the sample line. In Cramer's model, the peak concentrations occur at about 1,000 feet from the edge of the block. The location of the peak on this sample line's graph is significantly downwind from Cramer's model. This could be a result of droplet sizes that were smaller than assumed (in Cramer's model) and local meteorlogical (wind) conditions.

Line "C" --

C-54 aircraft were used to apply Sevin-4-Oil to block 14-1 located south of Masardis. The sample line was located north of the block, parallel with the lines of flight. The wind was from the west, creating a <u>cross wind</u> monitoring arrangement. (Figure 4, page 8).

Figure 14 depicts graphically the data shown in Table 4. It should be noted that the graph from the edge of the block to 1/8 mile out-of-block was projected by use of Cramer's model. It is felt that the data obtained from the edge-of-block and in-block locations were not representative because the spray planes were overhead as these stations were being set up.

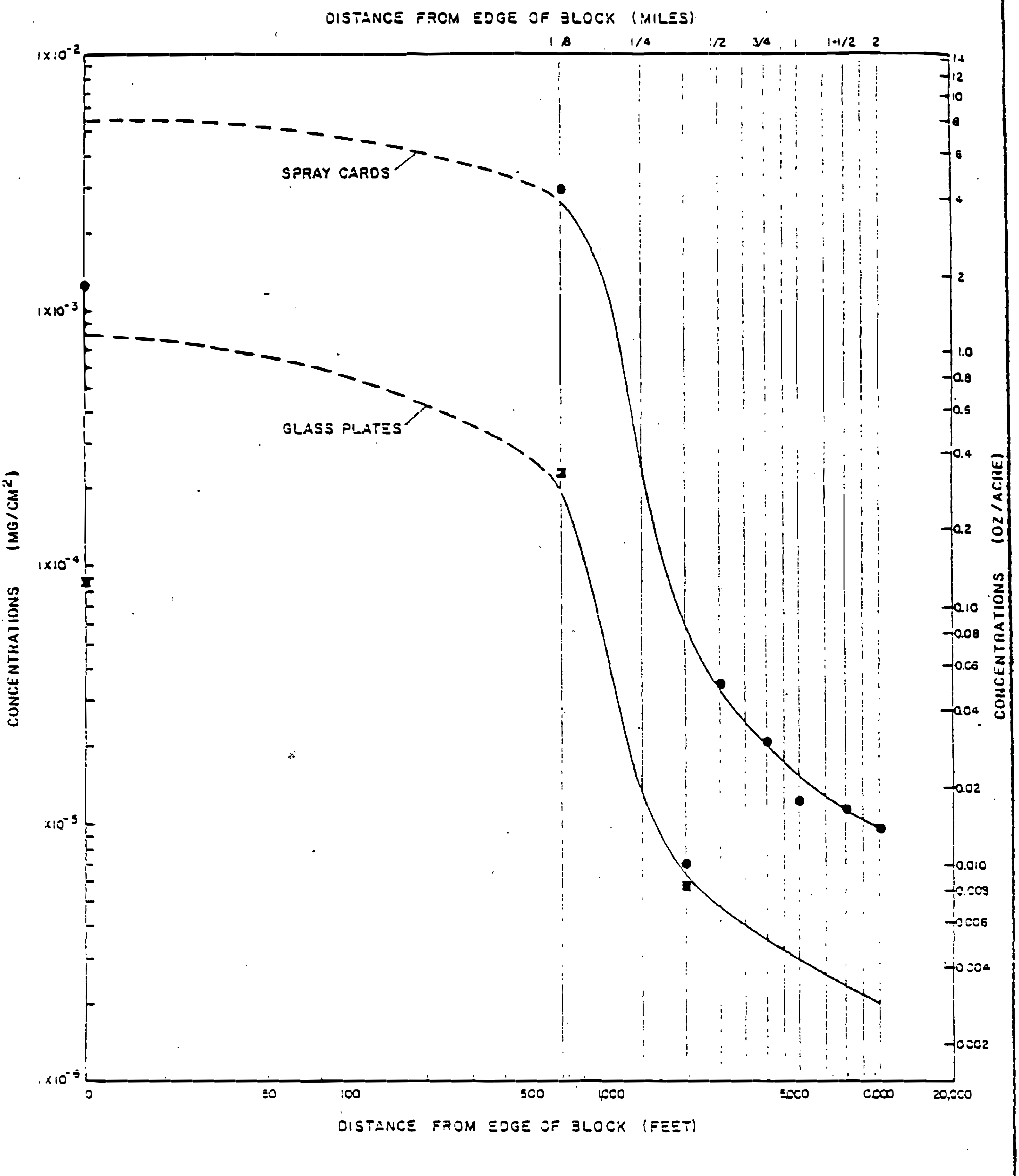
The mass deposits projected at the edge of the block represent about 7 oz/acre application rate which is 60 percent of the intended in-block application rate (11.76 oz/acre of active ingredient). The mass deposit remained relatively uniform for



Line of Flight Perpendicular to Sample Line - Downwind Monitoring

FIGURE 13. $\frac{\text{"B" LINE}}{30-5}$

MASS DEPOSIT AS A FUNCTION OF DISTANCE FROM THE EDGE OF SPRAY BLOCK.



Line of Flight Parallel to Sample line - Crosswind Monitoring

FIGURE 14. "C" LINE / 14-1

MASS DEPOSIT AS A FUNCTION OF DISTANCE FROM THE EDGE OF SPRAY BLOCK.

about 800 feet out-of-block and then dropped off sharply. At 2,000 feet out-of-block, the mass deposits were reduced to 0.72 oz/acre or 6 percent of the in-block application rate.

Line "E" --

Spray block 13-10, located northwest of Sugarloaf Mountain (Figure 3) was sprayed with Sevin-4-Oil by TBM aircraft, with lines of flight running north-south and the wind from the west. The sample line was perpendicular to the lines of light and downwind.

The mass deposit at the edge of the block was 0.1 oz/acre or 0.8 percent of the intended in-block application rate. The mass deposit remained uniform for 300 to 400 feet, then increased to a maximum of 0.14 oz/acre at 1/8 mile (660 feet) out-of-block. The mass deposit then dropped off substantially to 0.01 oz/acre (which is less than 0.1 percent of the in-block application rate) at the end of the sample line.

The graph (Figure 15) obtained from the spray card data corresponds well with Cramer's model for downwind monitoring and a perpendicular application. Again, the glass plate data were lower than the data obtained with the spray cards.

Line "F" --

Sevin-4-Oil was applied to spray block 9-8, located west of Oxbow Plantation, by C-54 aircraft (Figure 5). The sample line was located east of the spray block. The lines of flight ran north-south, creating a sampling condition of monitoring perpendicular to the lines of flight. No wind was recorded by meteorological equipment or by any monitoring reports.

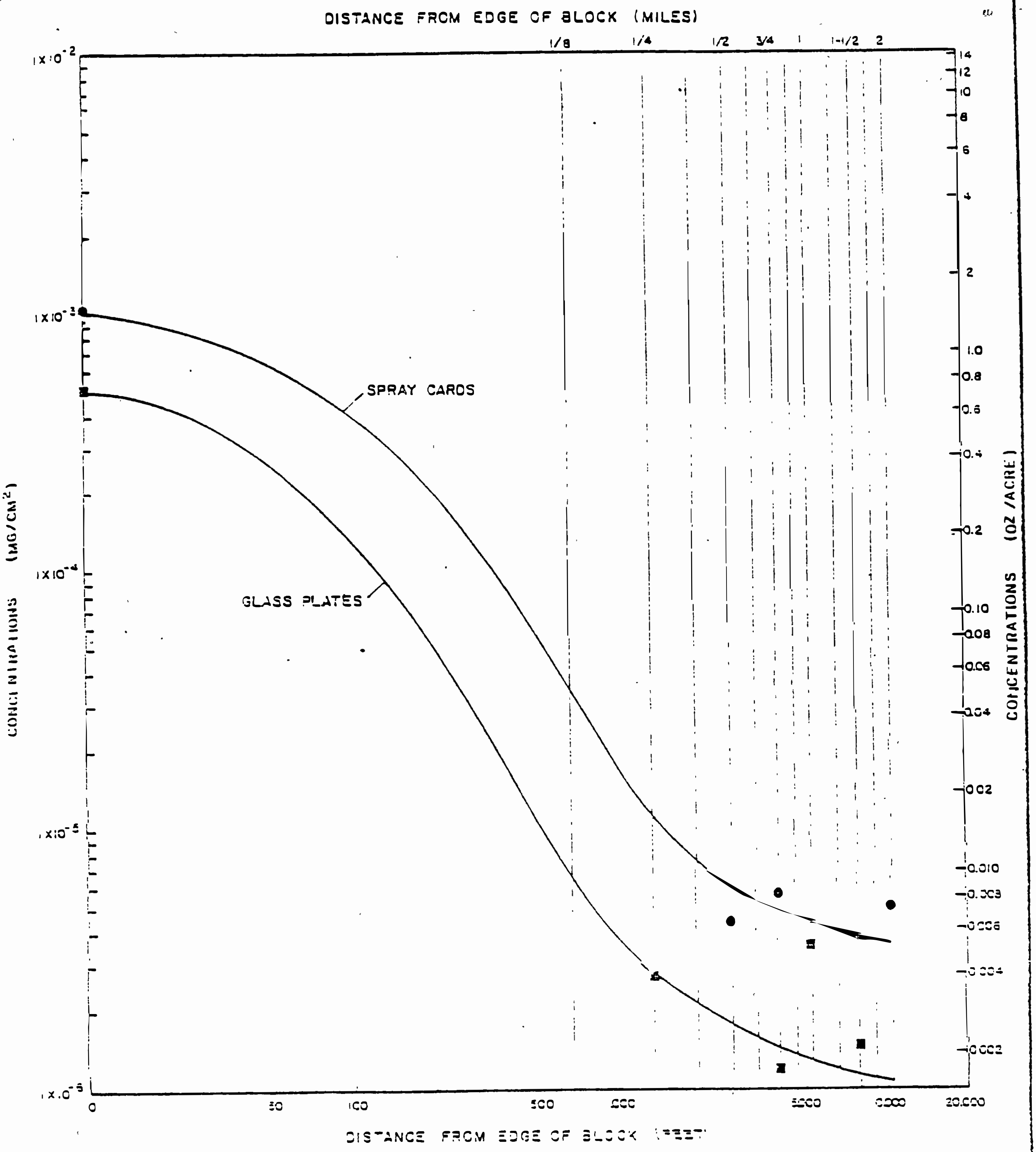
Mass deposits recorded at the edge of the block were 1.43 oz/acre or about 12 percent of the expected in-block application rates. The mass deposit decreased uniformly to 0.14 oz/acre at 300 feet out-of-block and 0.10 oz/acre at 1,200 feet. These deposits represent 1.2 and 0.12 percent, respectively, of in-block application rates.

Again, there was a difference between the glass plate and spray card data. The glass plat graph (Figure 16) was uniformly lower than the spray cards.

Line "G" --

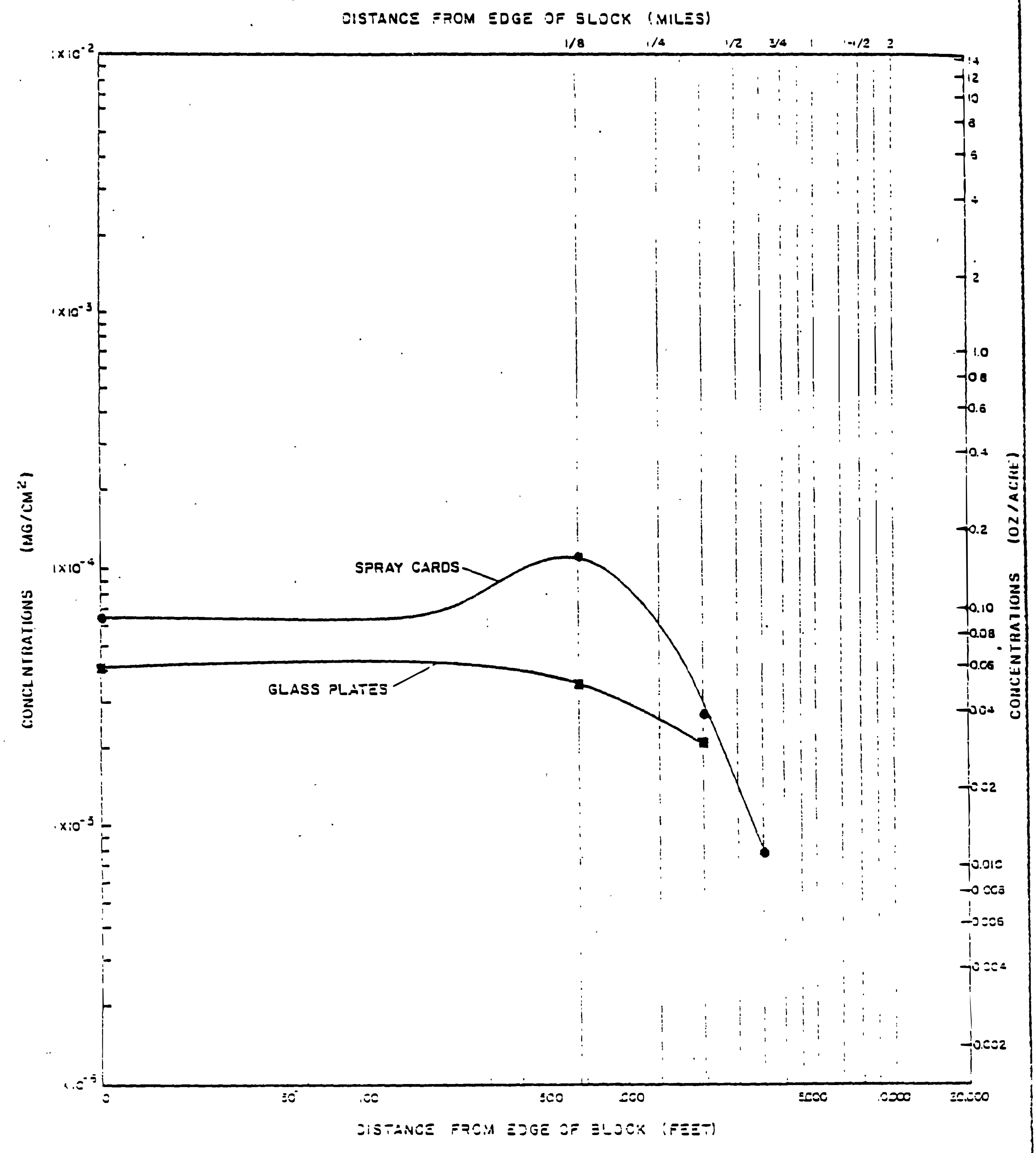
Sample line "G" was used to monitor airborne drift from spray block 14-6, located north of Knowles Corner in Moro Plantation (Figure 6). C-54 aircraft applied Sevin-4-Oil to this block. The line of flight was north-south, enabling the sample line to be parallel to the sample line. The wind direction was from the west, creating a cross wind monitoring condition.

Mass deposit (as determined from the spray cards) at the block edge was 5.7×10^{-5} mg/cm^2 (0.08 oz/acre), which represents



Line of Flight Perpendicular to Sample Line - No Wind Monitored

FIGURE 16. "F" LINE
9-8
MASS DEPOSIT AS A FUNCTION OF DISTANCE FROM THE EDGE OF SPRAY BLOCK.



Line of Flight Perpendicular to Sample Line - Downwind Monitoring

FIGURE 15. "E" LINE / 13-10

MASS DEPOSIT AS A FUNCTION OF DISTANCE FROM THE EDGE OF SPRAY BLOCK.

0.7 percent of the in-block application rate. The deposit remained nearly constant for nearly 1-1/2 miles. Between the 1-1/2 and 2-mile stations, the mass deposit dropped by 70 percent (Figure 17).

The plot of the curve for the mass deposit on the glass plates was higher than the plot for the spray cards until after the 1-mile station. The low value at the 1/2-mile station was not representative as the plate was knocked over.

Particle Size Spectrum

A second tool often used to describe airborne drift other than mass deposit, is that of particle size spectrum. The degree of atomization of the spray affects its drift characteristics.

Conventional nozzles produce a range of droplet sizes with varying numbers of droplets in each size category. From previous research by Maksymiuk and Isler and Thompson, as sited in USDA Technical Bulletin 1596, it is know that smaller-sized droplets are sensitive to meteorological conditions. Therefore, such droplets are more difficult to control.

It can be seen that a compromise is necessary. Too many small droplets could have greater potential for reaching non-target areas. Conversely, large droplets, which are easier to control with respect to drift, would produce lower than desired insect mortalities.

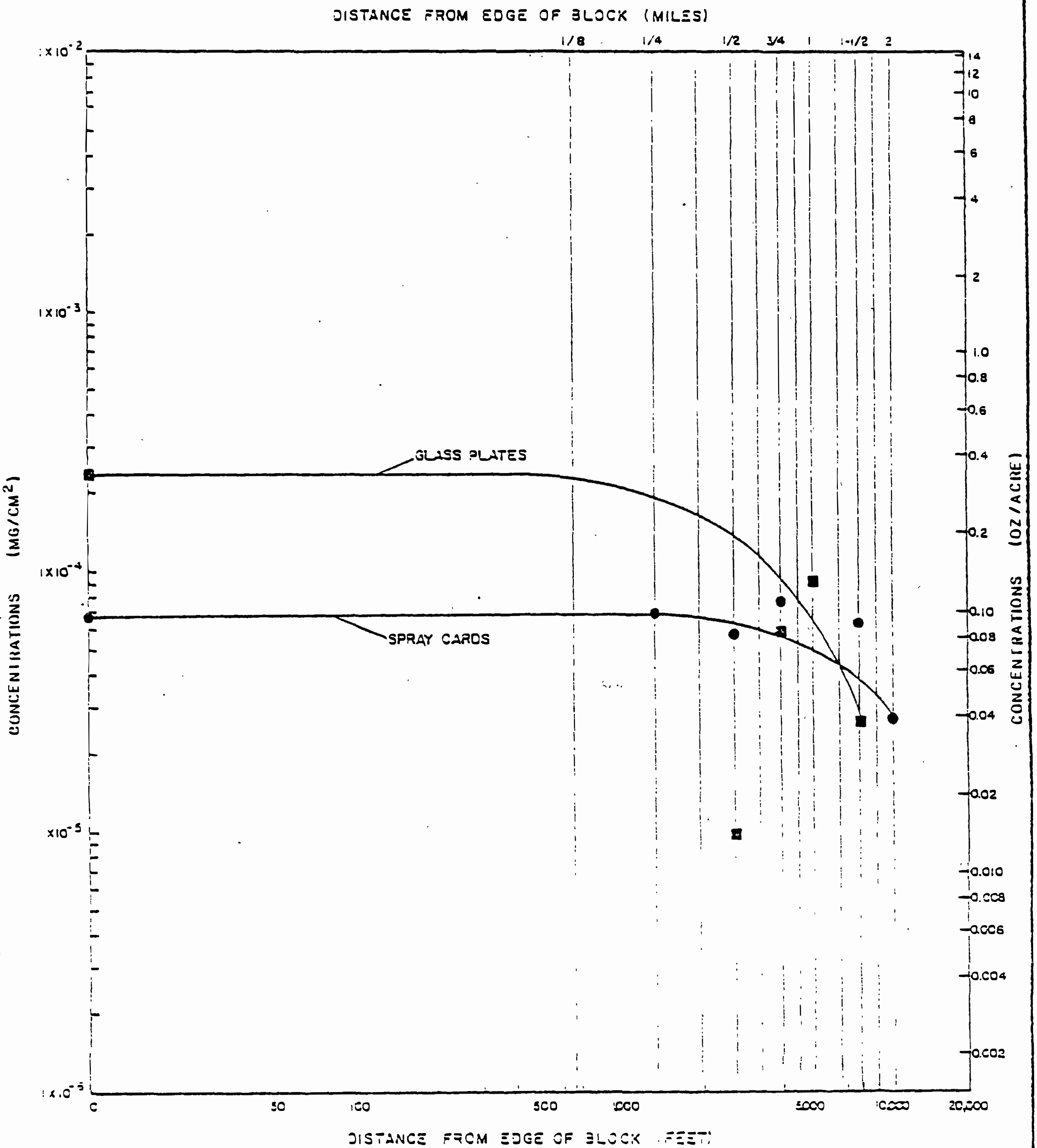
Tables which show the number of droplets of various sizes counted at each sample station can be found in Appendix B. For Dylox, droplets up to 100 m in diameter were encountered at the 1/8-mile into-block, edge-of-block and 1/8-mile out-of-block stations. One line "A", no spray was encountered beyond the 1/8-mile station, except for a few random droplets where the planes crossed the sample line. On line "B", droplets up to 59 μm in diameter were encountered all the way to the 7/8-mile station.

For Sevin-4-Oil, droplets with diameters between 10 μm and 69 μm (the smallest two size categories) were encountered beyond the 1/4-mile station. Droplets with larger diameters did occur inside the block and at stations to and including the 1/4-mile station.

Table 5 shows the relationship between the number of droplets and the equivalent mass of each size category for both Dylox and Sevin-4-Oil. A quick review of the table reveals that hundreds of smaller droplets (0 μm - 33 μm diameter for Dylox and 10 μm - 69 μm for Sevin-4-Oil) are necessary to create the mass of one larger droplet (59 μm - 72 μm diameter for Dylox and 130 μm - 162 μm for Sevin-4-Oil).

CONCLUSIONS

A review of the tables and graphs contained in the previous subsection supports the following observations:



Line of Flight Parallel to Sample Line - Downwind Monitoring

FIGURE 17. "G" Line / 14-6

MASS DEPOSIT AS A FUNCTION OF DISTANCE FROM THE EDGE OF SPRAY BLOCK

TABLE 5. RELATIONSHIP OF MASS OF THE VARIOUS SIZE CATEGORIES USED IN THE MONITORING PROGRAM

NUMBER OF DROPLETS TO GENERATE AN EQUAL MASS OF ONE DROPLET OF ANOTHER SIZE CATEGORY

Size Category	Size Category 1	2	3	4	5	6	7	8	9
DYLOX									
1	+	8.9	29.1	68.1	130.9	223.6	353.7	510.6	727.6
2	-	+	3.3	7.6	14.6	25.0	39.5	57.1	81.4
3	-	-	+	2.3	4.5	7.7	12.2	17.5	25.0
4	-	-	-	+	1.9	3.3	5.2	7.5	10.7
5	-	-	-	-	+	1.7	2.7	3.9	5.6
6	-	-	-	-	-	+	1.6	2.3	3.3
7	-	-	-	-	-	-	+	1.5	2.0
8	-	-	-	-	-	-	-	+	1.4
9	-	-	-	-	-	-	-	-	+
SEVIN									
1	1.0	8.2	29.6	74.1	152.9	278.4	464.7	729.4	1088.0
2	-	1.0	3.6	9.0	18.5	33.8	56.4	88.5	132.0
3	-	-	1.0	2.5	5.2	9.4	15.7	24.6	36.8
4	-	-	-	1.0	2.1	3.8	6.3	9.8	14.7
5	-	-	-	-	1.0	1.8	3.0	4.8	7.1
6	-	-	-	-	-	1.0	1.7	2.6	3.9
7	-	-	-	-	-	-	1.0	1.6	2.3
8	-	-	-	-	-	-	-	1.0	1.5
9	-	-	-	-	-	-	-	-	1.0

- The results of the monitoring effort appeared to correspond well to Cramer's model, which was developed to predict deposition and drift.
- Table 6 summarizes the relationship of mass deposit with distance for the various orientations encountered in the monitoring effort.
- Wind direction played a critical role in the extent of drift.
- Mass deposits at the edge-of-block were substantially lower than expected in-block application rates.
- Only the small droplet sizes, 0μm - 33μm for Dylox and 10μm - 69μm for Sevin-4-Oil were encountered beyond 1/4 mile out-of-block.

AIRPORT AMBIENT AIR CONCENTRATIONS

The amount of insecticide released to the environment at the project airports is of concern because of the large number of personnel who must work in the vicinity of the spray planes and the insecticide mixing/loading areas. To determine the levels of insecticides in the ambient air, sampling was conducted at two of the airports. Millinocket and Presque Isle airports were chosen since they were the major airports used by the spray teams during the spray operations.

In order to determine the airborne concentrations of the insecticide (Sevin-4-Oil) being used at the airports, high volume air samplers developed by the Mid-West Research Institute were utilized. The samplers were operated by Bureau of Forestry personnel familiar with the scheduling of the spray operations.

RESULTS

Millinocket Airport

Samples were taken at the Millinocket airport over a continuous 4-day period. Laboratory results of the samples showed that concentrations of pesticide were lower than the minimum detectable level of 10 ng/m^3 (Table 7). These results are not surprising since transfer of pesticide was accomplished by pumping from tank trucks directly into planes. In addition mixing of the pesticide was done at another site, eliminating potential concentrations of pesticide in the air.

Presque Isle Airport

Samples at the Presque Isle airport were taken over three separate 24-hour periods during the week of June 2 - 10, 1979. Concentrations detected ranged from 60 to 80 ng/m^2 with one exception (Table 8). A relatively high value of 533 ng/m^3 was recorded

TABLE 6

SUMMARY OF MASS DEPOSIT VS. DISTANCE AND CONDITIONS

Sample Line/Block	Orientation of Line of Flight to Sample Line	Orientation of Wind to Sample Line	Percentage of Edge-of-Block Mass Deposit at			
			1,000'	3,000'	5,000'	10,000'
A/30-5	Parallel	Crosswind	<1%			
B/30-5	Perpendicular	Downwind	<10%		Increased to 40%	
C/14-1	Parallel	Crosswind	<10%	<1%		
E/13-10	Perpendicular	Downwind	100%	10%		
F/9-8	Perpendicular	No wind	<1%			
G/14-6	Parallel	Downwind	100%		100%	20%

TABLE 7. AMBIENT AIR CONCENTRATIONS OF SEVIN-4-OIL AT AIRPORTS

Sample Number	Sample Date (begun in p.m.)	Sample Period	Concentration (ng/m^3)
Millinocket Airport			
1A	6/1 - 6/2	First 12 hr	<10
1B		Second 12 hr	<10
2A	6/2 - 6/3	First 12 hr	<10
2B		Second 12 hr	<10
3A	6/3 - 6/4	First 12 hr	<10
3B		Second 12 hr	<10
4A	6/4 - 6/5	First 12 hr	<10
4B		Second 12 hr	<10
Presque Isle Airport			
5A	6/2 - 6/3	First 12 hr	66.6
5B		Second 12 hr	64.7
6A	6/5 - 6/6	First 12 hr	77.6
6B		Second 12 hr	61.0
7A	6/9 - 6/10	First 12 hr	533.0
7B		Second 12 hr	65.4

TABLE 8.

OCCURRENCE OF SPRAY AND SAMPLING OPERATIONS AT MILLINOCKET AND PRESQUE ISLE AIRPORTS

Date	Millinocket AM	Millinocket PM	Presque Isle AM	Presque Isle PM	Date	Millinocket AM	Millinocket PM	Presque Isle AM	Presque Isle PM
5/27		X			6/8	X		X	
5/28					6/9				0
5/29					6/10			0	0
5/30					6/11				
5/31				X	6/12				
6/1	X	X0	X	X	6/13				
6/2	X0	0	X	0	6/14	X		X	
6/3	0	0	0	0	6/15				
6/4	X0	0	X		6/16	X			
6/5	0	0	X	0	6/17	X		X	X
6/6			0	X0	6/18			X	
6/7	X	X	X	X	6/19			X	

X = Periods during which spraying occurred from that airport base.

0 = Periods during which air sampling occurred.

for the first 12-hour period on June 9, 1979. A check with personnel familiar with operations performed at that time indicated no unusual occurrences. From discussions with laboratory personnel, it is theorized that this high value is due to several large random droplets of pesticide being collected by the air sampler. This situation would weight the concentration correspondingly.

The higher and relatively consistent values recorded at the Presque Isle airport were due to:

- Sampler location, which was downwind from operations and therefore able to collect entrained pesticides in the air.
- Mixing of the pesticides which was performed at the airport.

It should be noted that no spraying occurred when the high concentration was recorded. (Table 8).

SUMMARY

The results obtained during the monitoring period indicate that minimal levels of insecticide were detected at Millinocket airport. High levels of insecticides were detected at Presque Isle. Presumably these levels were a result of storing and mixing pesticide at the airport.

V. ANALYSIS OF WATERBORNE PESTICIDE DRIFT

Waterborne pesticide drift was monitored by collecting water and stream sediment samples from streams which flowed out of spray blocks. The procedures used to obtain samples have been discussed previously. This section will discuss the analytical procedures used to obtain the results, as well as discussion of the results.

LABORATORY ANALYSIS OF WATER AND SEDIMENT SAMPLES

The analytical methods used by the Public Health Laboratory are recognized to be effective and accurate for determining pesticide concentrations in water and sediment samples.

Water

The analytical methods used for determination of such concentrations in water were:

- Orthene - A variation of the method "Gas Liquid Chromatographic Determination of Acephate and Ortho 9006 Residues in Crops", JAOA6, Vol. 57, No. 1, 1974, pp 189-191.
- Dylox - A variation of the method "Determination of Trichlorfon in Forest Environmental Samples", Journal of Agriculture and Food Chemistry, Vol. 21, No. 6, Nov/Dec 1973, p 1095.
- Sevin-4-Oil - "Gas Liquid Chromatographic Analysis of Carbamate Pesticides and Phenolic Compounds in Water", American Laboratory Magazine, Dec. 1972.

Sediment

The analytical methods used for determination of such concentrations in bottom sediments were:

- Orthene - No analyses were performed due to the low concentration of Orthene found in the water samples. In addition, unforeseen budgeting constraints precluded conducting the analyses.
- Dylox - Same method as noted for water.
- Sevin-4-Oil - "Determination of Carbaryl Residue in Pond Mud", Union Carbide Corp., followed by method noted in water section.

RAINFALL

An important parameter which undoubtedly influenced the results was rainfall. Basically, the intensity, frequency, and cumulative amounts or rainfall will affect the results in two ways. First, runoff will carry pesticides off the sprayed areas and into the streams. Second, the runoff will affect the level of flow in the streams. Following is a brief discussion of rainfall as it relates to the sampling program for each block.

Block 27-4

No rain was recorded between the pre-spray and 48 hour post-spray sample periods. Between two days post-spray and six-days post-spray, 0.73 inches of rain was recorded.

Block 9-6

During the post-spray period, rainfall occurred on a regular basis:

- 0.1 inches in the 24-hour period following spray application
- 0.05 inches between the 24-hour and 48-hour samples
- 1.25 inches between the 48-hour and 6 day samples.

Block 30-4

Rainfall occurred in this block on a regular basis as well.

- 0.15 inches in the first 24-hours following spraying
- 0.80 inches between the 24-hour and 48-hour samples
- 0.10 inches between the 48-hour and 6 day samples.

RESULTS

The results obtained in the field monitoring program showed substantial decreases in both water and sediment sample pesticide concentrations over the six-day monitoring period. In addition, increases in concentrations occurred as the result of rainfall. Results for pre-spray samples were negative.

Orthene

This pesticide was applied by helicopter on approximately 1,000 acres designated as block 27-4 (Figure 7, page 13). Alder Stream and the North Branch of the Dead River, located west of Stratton, were monitored. The watershed affecting the monitoring of this block is approximately 34,500 acres between the in-block sample point and the 2-mile sample point.

An additional 66,000 acre watershed, of the North Branch of the Dead River, enters after the 2-mile sample point, influencing the 4-mile sample point located on the North Branch of the Dead River.

Samples taken from Alder Stream showed no concentrations of Orthene or the breakdown product, Monitor, until the six-day monitoring period (Table 9). No results for sediment samples are shown as no analyses were performed. The results for the surface and subsurface (mid-level) samples are plotted in Figure 18.

Concentrations of Orthene were nearly the same in both surface and subsurface samples. Subsurface samples at the edge, 1/8-mile, 1/4-mile, and 1/2-mile locations were slightly higher than the surface samples. Monitor concentrations of subsurface samples at the 1/8-mile, 1/4-mile, and 1-mile locations were higher than surface samples.

The lack of pesticide concentrations until the six-day monitoring period is attributed to two circumstances. First, the pesticide was applied with helicopters and no direct hits were recorded. Second, there was no rain until after the 48-hour sampling period. Between the 48-hour and six-day periods, 0.73 inches of rain fell. The rain generated runoff which apparently carried the pesticide, Orthene, and its breakdown product, Monitor, into the stream. From the results, distribution through the profile was complete.

Sevin-4-Oil

This pesticide was applied by TBM aircraft on approximately 2,800 acres designated as block 9-6 (Figure 9, page 15). The North Branch of the Presque Isle Stream, located southwest of Presque Isle, was monitored. The spray block is located near the head waters of the stream. A total of 5,300 acres of watershed passed through the spray block and influenced the in-block to 1-mile sample points. A total of 16,500 acres of watershed influenced the stream at the 4-mile sample point.

Concentrations of Sevin-4-Oil in the North Branch of the Presque Isle Stream are shown in Table 10 and Figure 19. In comparison, the concentrations at the in-block sample station were substantially higher than other monitoring stations. Although, this is expected, the opposite has been noted where tributaries, passing through the spray block, have joined the

TABLE 9. 6 DAY[1] STREAM SURFACE AND SUBSURFACE CONCENTRATIONS OF ORTHENE AND MONITOR

ppb

	ORTHENE 6 Day		MONITOR 6 Day	
Location	Surface	Subsurface	Surface	Subsurface
In-Block	1.8	1.35	2.33	1.09
Edge	1.32	2.19	0.55	*
1/8 mile	1.72	1.92	2.89	12.18
1/4 mile	2.01	2.48	1.4	4.56
1/2 mile	1.91	2.67	*	*
1 mile	2.06	1.45	*	1.20
2 mile	4.97	1.31	1.44	0.89
4 mile	1.59	0.7	1.82	1.29

[1] Lab analysis negative to trace for one, 24, and 48 hour sample periods.

* Lab analysis negative

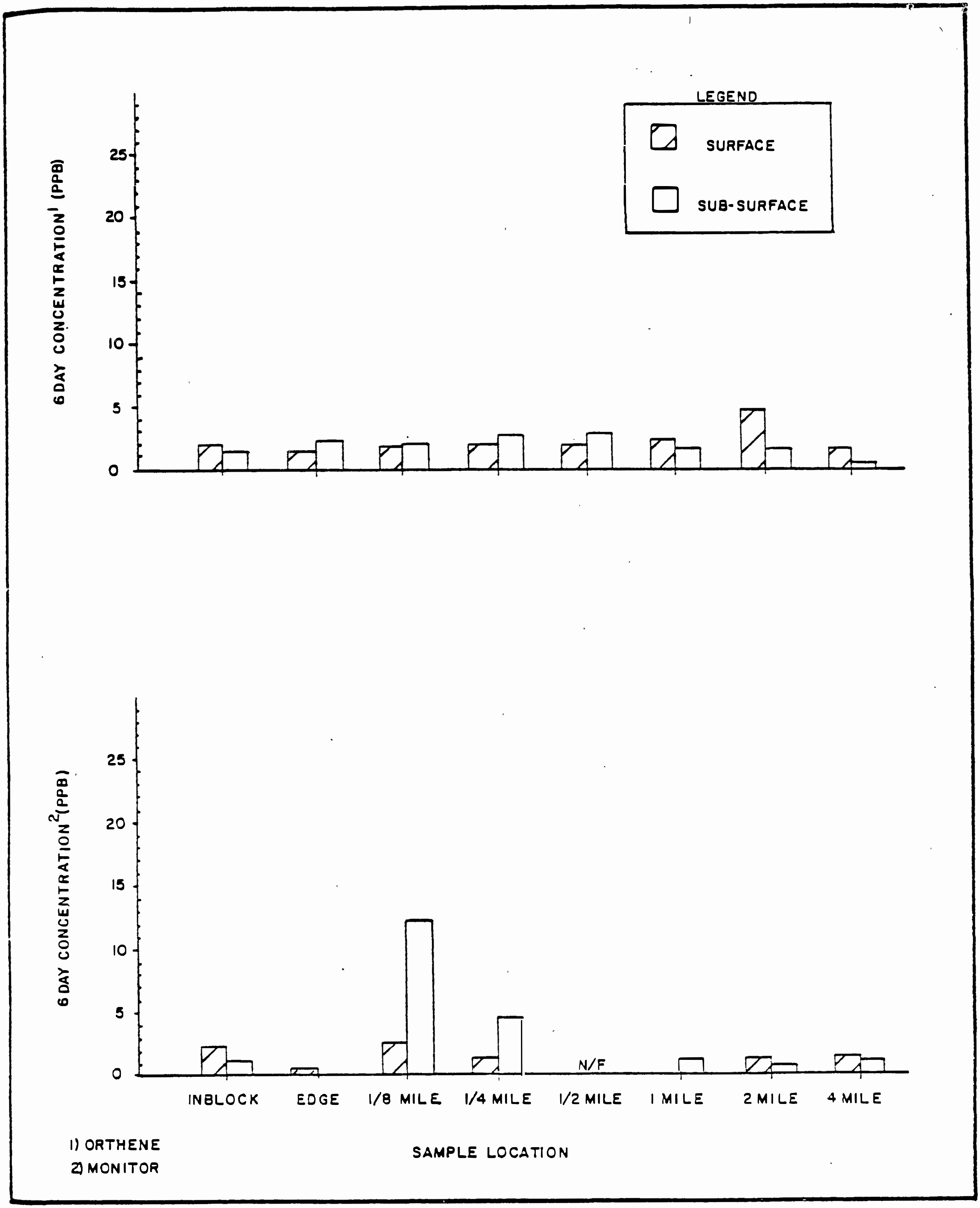


FIGURE 18: ORTHENE AND MONITOR 6 DAY STREAM SURFACE AND SUBSURFACE CONCENTRATIONS

TABLE 10. STREAM SURFACE AND SUBSURFACE SEVIN-4-OIL CONCENTRATIONS ppb

	8 Hour		24 Hour		48 Hour		6 Day	
Location	Surface	Subsurface	Surface	Subsurface	Surface	Subsurface	Surface	Subsurface
In-Block	13.8	15.3	28.6	32.3	6.9	14.9	6.4	5.3
Edge	0.30	0.29	0.18	0.16	0.10	0.10	0.25	0.38
1/8 mile	0.97	0.98	1.2	1.5	1.3	0.9	0.63	0.68
1/4 mile	0.36	1.21	1.2	1.7	1.0	1.5	0.50	0.59
1/2 mile	1.1	1.1	0.84	2.2	0.97	0.75	0.70	0.42
1 mile	5.3	5.0	3.3	2.1	3.6	3.0	0.80	0.45
2 mile	2.4	*	2.5	2.0	0.87	2.5	1.4	0.58
4 mile	0.82	0.71	2.4	2.0	1.6	1.7	1.5	0.68

* Lab analysis negative

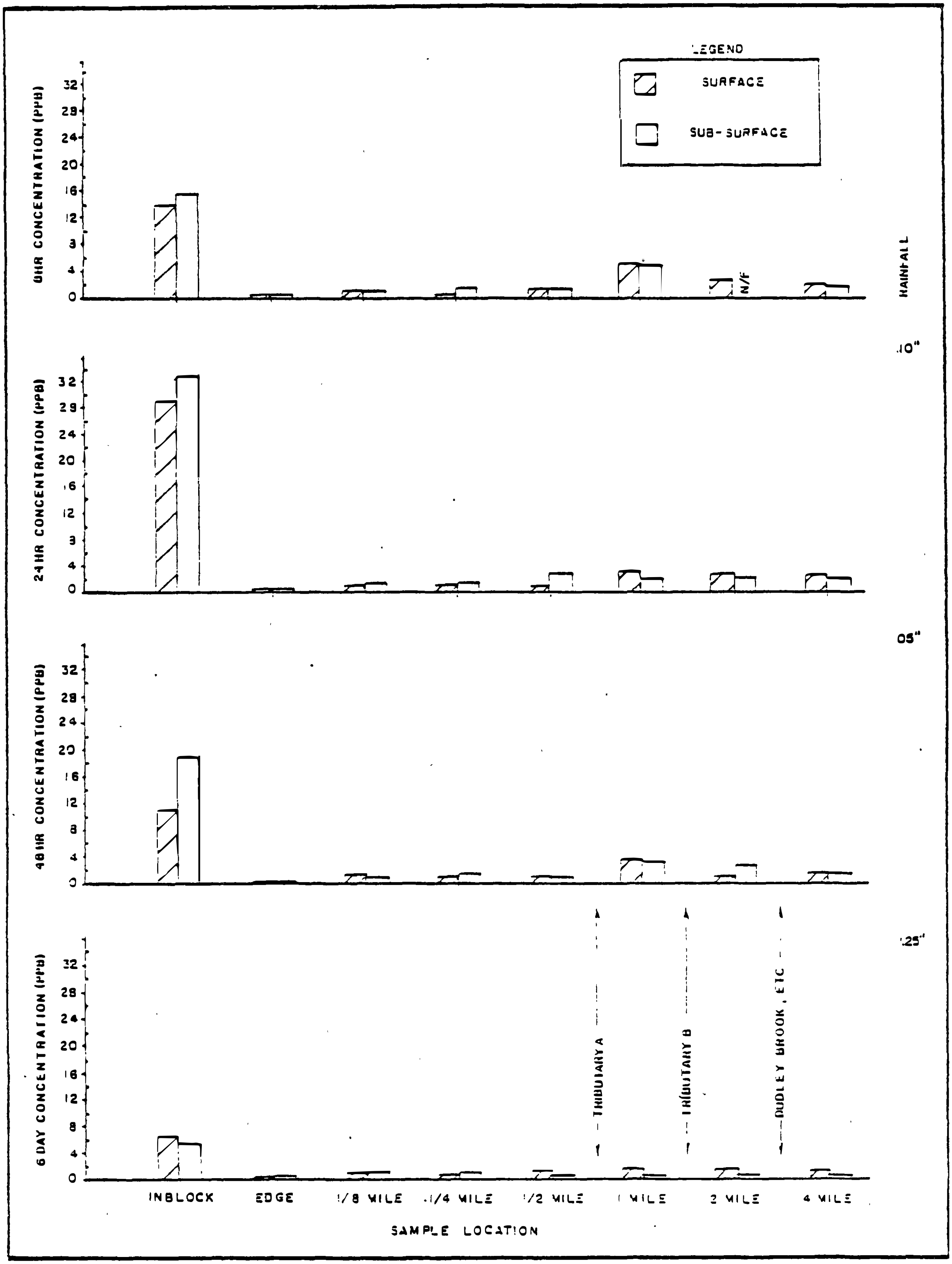


FIGURE 19.

SEVIN-4-OIL STREAM SURFACE AND SUBSURFACE CONCENTRATIONS

sample stream above the final monitoring station. These tributaries have added their transported pesticide to that of the stream, thus, producing a greater out-of-block concentration of pesticide in the stream. At the edge-of-block station, the tributary on which the in-block monitoring was performed, joins the North Branch of the Presque Isle Stream. The immediate dilution is shown by the marked drop in concentration.

A second tributary joins the North Branch between the 1/2-mile and 1-mile sample stations. A portion of the watershed was sprayed and the pesticide in the runoff increased the concentration at the downstream stations during later sample periods.

Concentrations of the subsurface samples were close to the surface values, but generally lower. No pesticide concentrations were found in the sediment samples. The lower subsurface values and the lack of pesticide in the bottom samples indicate that vertical movement is perhaps slow. These results are expected due to the fact that oil (lighter than water) is used as the carrier for this pesticide.

Dylox

This pesticide was applied by Thrush aircraft on approximately 4,100 acres designated as block 30-4 (Figure 8, page 14).

The monitoring began on Sam Ayers Brook and continued onto Mattamiscontis Stream, which is located northwest of Lincoln. The watershed passing through the spray block includes 15,000 acres and influences the in-block to 1/2-mile sample points. An additional 30,500 acres of watershed are added to the monitored stream when Ayers Brook joins the Mattamiscontis. This, along with 1,300 acres of watershed from Halfway Brook, influences the 2-mile sample point. Nine thousand additional acres of watershed influence the Mattamiscontis at the 4-mile sample point.

Concentrations of Dylox were substantial through the 48-hour sampling period. Rainfall occurred between each sampling period and apparently the runoff carried the water-soluble Dylox into the stream. At the one-hour sampling period, concentrations were recorded at all sampling stations. Concentrations decreased beyond the 1/8-mile sampling station. The high concentrations of the sediment samples show that Dylox travels vertically through the profile quite rapidly. Concentrations for the 24- and 48-hour sampling periods showed high concentrations in both surface and subsurface samples. Subsurface samples showed concentrations very close to the surface samples, indicating rapid vertical movement through the profile. (Table 11 and Figure 20.)

By the six-day sampling period, the concentrations had dropped significatnly to less than 4.0 ppb. Again, the concentrations were uniform throughout the profile. The low concentrations were attributed to the reduction in pesticide levels due to the natural half-life process and the lost of pesticide due to runoff.

CONCLUSIONS

A review of the results indicates that the impact of the spraying is relatively short-lived. Concentrations at the six-day sample period were significantly lower than earlier concentrations. Other findings include:

- Watershed impact can be expected and is unavoidable. Runoff generated from rainfall will carry pesticide from the watershed into the stream.

- Rainfall and runoff impact on stream concentrations decrease with time as a result of levels of pesticides being reduced by natural degradation processes and by previous pesticide runoff removal.

- Dylox appears to be most sensitive to rainfall and runoff when compared to Sevin-4-Oil and Orthene.

- Dylox travels uniformly throughout the stream profile.

- Dylox has an impact on sediment concentration initially, but is removed with time.

- Sevin-4-Oil appears to be more resistent to removal by runoff as evidenced by substantially lower concentrations.

- Because of its carrier (oil), Sevin-4-Oil does not travel as readily throughout the stream profile.

- It is not know whether initial concentrations of pesticides in the streams are due to drift over the buffered area, or due to violation of the buffer policy, or both.

- Pesticides do not appear to be deposited in streams when applied by helicopter; however, after application by fixed-wing aircraft, pesticides are found in streams.

TABLE 11. STREAM SURFACE, SUBSURFACE, AND SEDIMENT DYLOX CONCENTRATIONS ppb

	One Hour			24 Hour		48 Hour		6 Day		
Location	Surface	Subsurface	Sediment	Surface	Subsurface	Surface	Subsurface	Surface	Subsurface	Sediment
In-Block	24.8	8.4	55.0	12.3	24.5	23.2	19.8	3.7	2.6	<2.9
Edge	34.2	8.2	164.6	21.1	21.1	24.8	23.6	2.9	2.6	3.3
1/8 mile	8.8	8.5	38.4	19.4	19.3	20.6	15.6	2.0	2.8	*
1/4 mile	*	1.9	35.6	18.7	14.9	23.2	17.9	1.6	3.0	2.1
1/2 mile	3.3	*	31.5	22.6	11.8	19.0	25.3	1.6	2.8	3.0
1 mile	-	-	-	-	-	-	-	-	-	-
2 mile	8.0	*	11.1	23.2	21.3	48.1	27.2	1.3	1.3	3.2
4 mile	0.90	*	10.5	11.6	14.5	28.5	37.9	1.2	1.0	<2.9

* Lab analysis negative
\- No sample at location

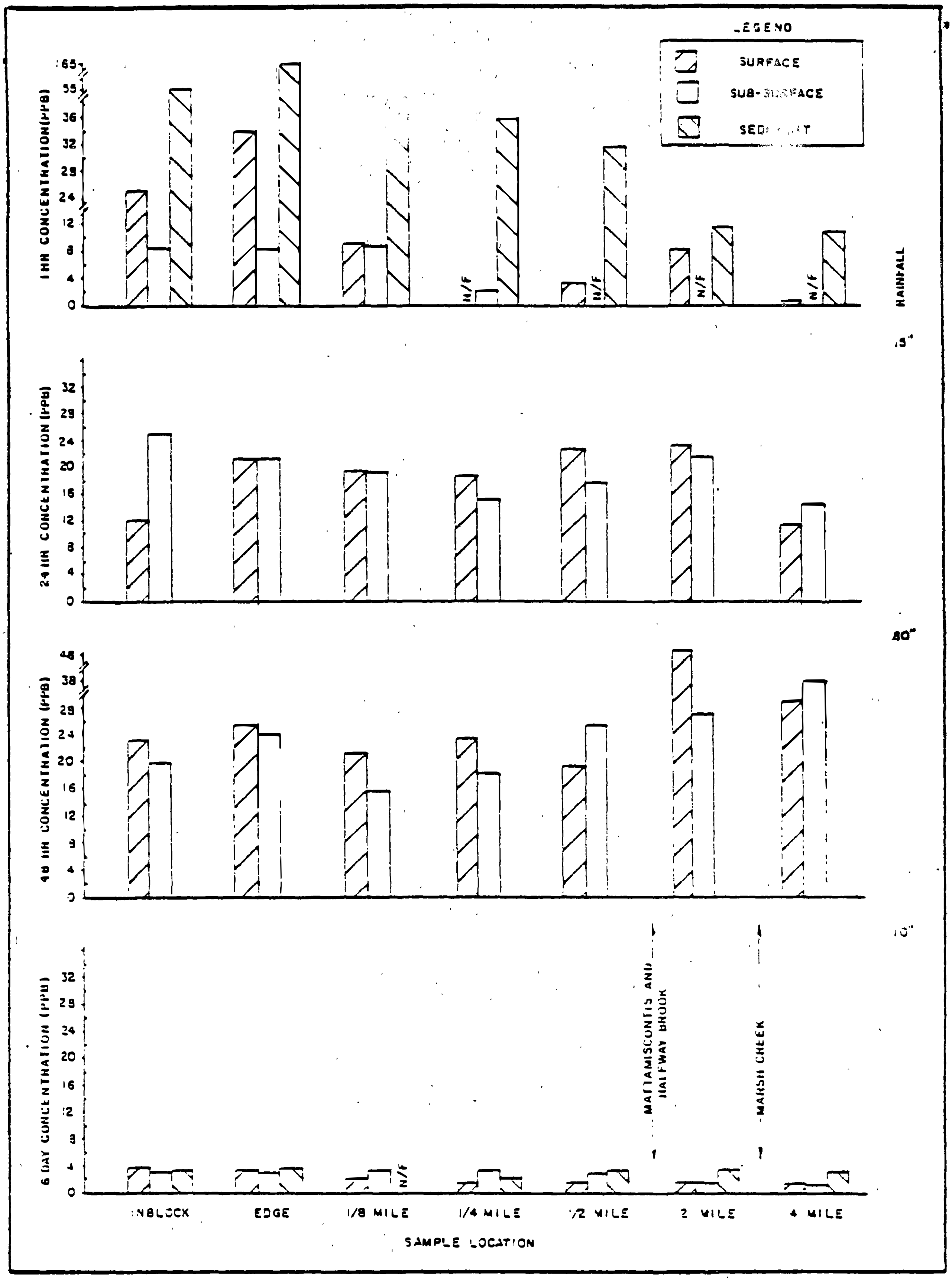


FIGURE 20.

DYLOX STREAM SURFACE, SUBSURFACE, AND SEDIMENT CONCENTRATIONS

VI. ANALYSIS OF PESTICIDE PRESENCE AND PERSISTENCE ON FOLIAGE AND LEAF LITTER

Pesticide presence and persistence were monitored by sampling foliage from spray blocks where airborne pesticide drift was monitored. The procedures used to obtain these samples have previously been discussed. This section will discuss the procedures used to obtain the results as well as a discussion of the results.

LABORATORY ANALYSIS OF FOLIAGE AND LEAF LITTER SAMPLES

Sample Preparation

As samples were requested by the Public Health Laboratory, they were taken out of storage, logged, prepared, and delivered. Leaf litter samples required no preparation. However, the process used by the laboratory did require that the needles be removed from the branches or twigs. To minimize the loss of pesticide, only the branches or twigs were handled. The needles were removed by means of razor knives and allowed to drop directly into the Zip-Loc bags. Following this procedure, the samples were delivered to the laboratory.

Laboratory Analaysis

The analytical methods used by the Public Health Laboratory are recognized to be effective and accurate for determining Dylox and Sevin-4-Oil concentrations on foliage and litter samples.

Dylox --

The analytical procedure used for Dylox determinations was "Determination of Trichlorfon In Forest Environment Samples", reprinted from Journal of Agriculture and Food Chemistry, Vol. 21, No. 6, page 1095, Nov/Dec 1973.

The instrumentation utilized during this method was a gas liquid chromatograph equipped with a flame photometric detector.

Sevin-4-Oil --

The analytical procedure for Sevin-4-Oil determinations was an adaption of "AOAC Carbaryl Colorimetric Residue Method", taken from "A Method for the Determination of Residues of Carbaryl on Plant Foliage", Union Carbide, 1974. A spectrophotometer was used as part of these determinations.

Orthene --

Contract specifications did not require that Orthene be monitored in the foliage and leaf litter monitoring effort of this project.

RESULTS

Pertinent information relative to each sample location can be seen in Table 12. Foliage and litter results are combined for ease of presentation.

Dylox

The results of the monitoring for both foliage and litter in block 30-5 show an expected decrease in concentration over time (Table 13). The slight variations in concentration at 30, 60 and 90 days are a result of the sampling technique. Each successive sample taken at a monitoring location was, by necessity, different. Therefore, the variation in concentrations was expected, particularly at such low concentrations.

The concentrations shown in Table 13 are plotted in Figure 21. The dramatic decreases between 1 day and 7 days post-spray can be seen. Dylox concentrations on foliage decreased by 99.5 percent by 7 days post-spray. Concentrations on litter decreased by 94.2 percent in the same period. Traces of the pesticide were found throughout the 90 day sample period.

Sevin-4-Oil

Four spray blocks were monitored for the presence and persistence of Sevin-4-Oil on foliage and litter samples.

Foliage --

The results of our monitoring effort are summarized in Table 14 and plotted in Figure 22. As can be seen, two blocks (13-10 and 14-1) showed pesticide concentrations. Two other blocks (9-8 and 14-6) showed no pesticide concentration at all. It should be noted that the concentrations shown are not Sevin-4-Oil, but alpha-naphthol, the metabolite of Sevin-4-Oil.

Discussion with Union Carbide officials and laboratory personnel failed to uncover any reasons why

- alpha-naphthol was found instead of Sevin-4-Oil on foliage samples, and
- no pesticide was found on foliage in two of the blocks,

since proper handling and storage techniques were practiced. All litter samples for these blocks showed concentrations of both Sevin-4-Oil and alpha-naphthol.

The concentration of alpha-naphthol in block 13-10 decreased by 84.3 percent by 14 days post-spray and by 19.2 percent in block 14-1 in 7 days. It should be noted that the above decomposition rates are for the alpha-naphthol, which is the first phase in the decomposition of Sevin-4-Oil.

TABLE 12. PARAMETERS AND INFORMATION ON FOLIAGE AND LEAF LITTER SAMPLE SITES

	DYLOX	SEVIN-4 OIL			
	Block 30-5	Block 13-10	Block 14-1	Block 9-8	Block 14-6
Associated Spray Line Designation	Line - B	Line - E	Line - C	Line - F	Line - G
Type of Aircraft	Thrush	TBM	C-54	C-54	C-54
Approximate Height of Aircraft Over Canopy	50	50	150	150	150
Direction of Spray Application Relative to Sample Line	Perpendicular	Perpendicular	Parallel	Perpendicular	Parallel
Direction of Wind Relative to Sample Line	Parallel	Parallel	Perpendicular	None	Parallel
Wind Direction (compass)	Southeasterly	Westerly	Westerly	None	Northwesterly
Meteorological Data	56^{o}-57^{o}F 85% H	40^{o}-60^{o}F 65%± H	53^{o}-66^{o}F 70%± H	59^{o}-61^{o}F 62%± H	43^{o}-56^{o} 70%± H
Date and Time of Spray Application	5/28 AM	6/7 AM	6/7 AM	6/7 AM	6/14 AM
Time of Initial Sampling After Spray	1 hour	1 hour	1 hour	1 hour	1 hour
Spray Block Location	At Gray's Hill - 2.5 Miles Southwest of Lincoln	4 Miles Northwest of Shin Pond	4 Miles South of Masardis	6 Miles West of Oxbow	1 Mile North of Knowles Corner
Spray Block Topography	Level - Sloping	Level - Gently Sloping	Level - Gently Sloping	Rolling - Hilly	Rolling - Hilly
Canopy Cover at Sample Site	Open	Open	Open	Open	Open

TABLE 13. DYLOX CONCENTRATION ON FOLIAGE AND LITTER SAMPLES IN BLOCK 30-5

	Concentration (ppm)	
Day	Foliage	Litter
1 (one hour)	32.17	12.80
7	0.185	0.75
14	0.02	0.95
30	*	0.069
60	0.05	0.67
90	*	0.074

* Pesticide not found during analysis.

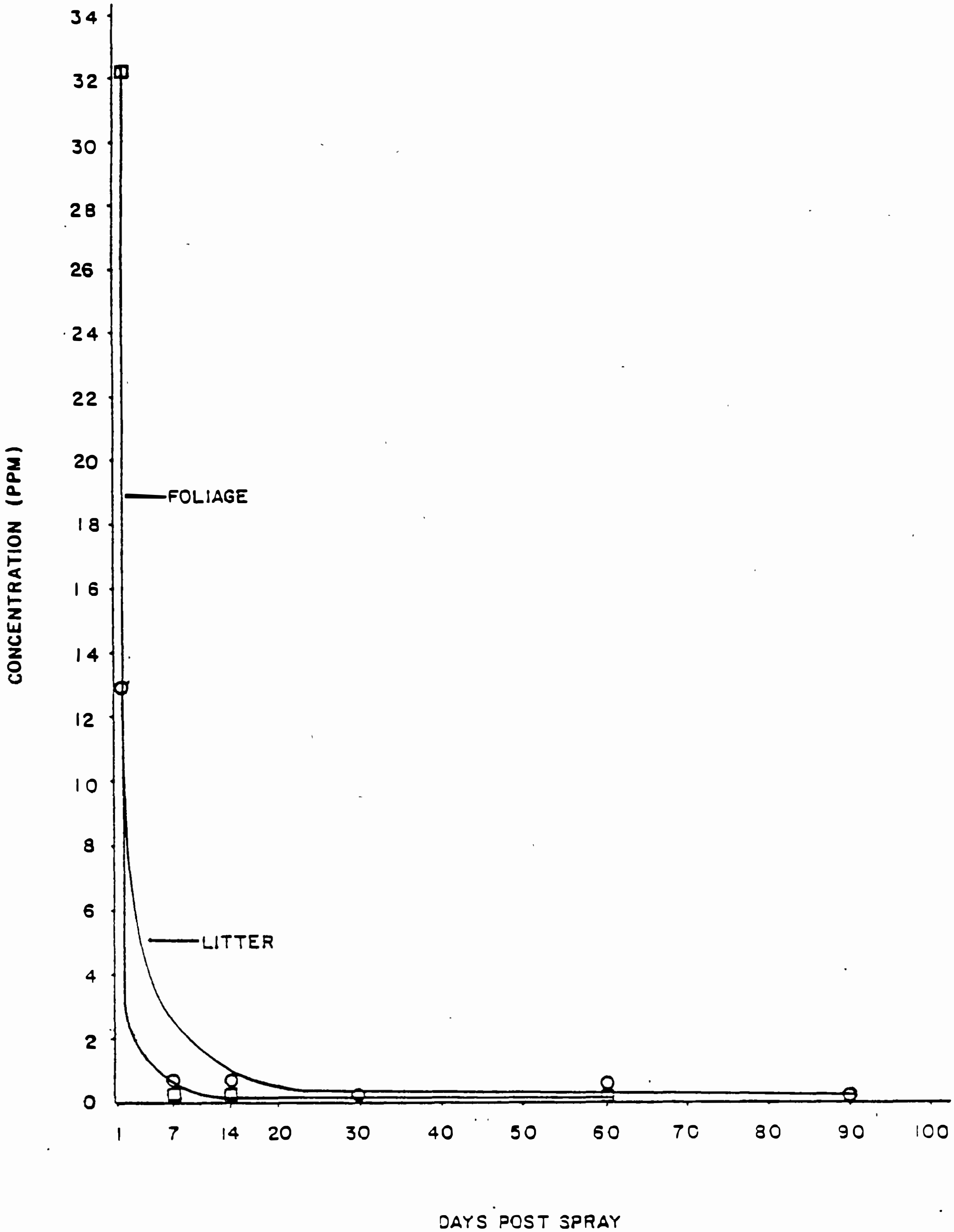


FIGURE 21. DYLOX CONCENTRATIONS ON FOLIAGE AND LITTER IN BLOCK 30-5 OVER TIME

TABLE 14. ALPHA-NAPHTHOL CONCENTRATION ON FOLIAGE IN BLOCK 13-10 AND BLOCK 14-1

Day	Concentration (ppm/wt) Block 13-10	Block 14-1
1 (one hour)	12.25	2.30
7	+	1.86
14	1.93	1.25
30	0.22	0.70
60	0.22	*
90	0.28	*

+ Sample lost during analysis
* Pesticide not detected during analysis

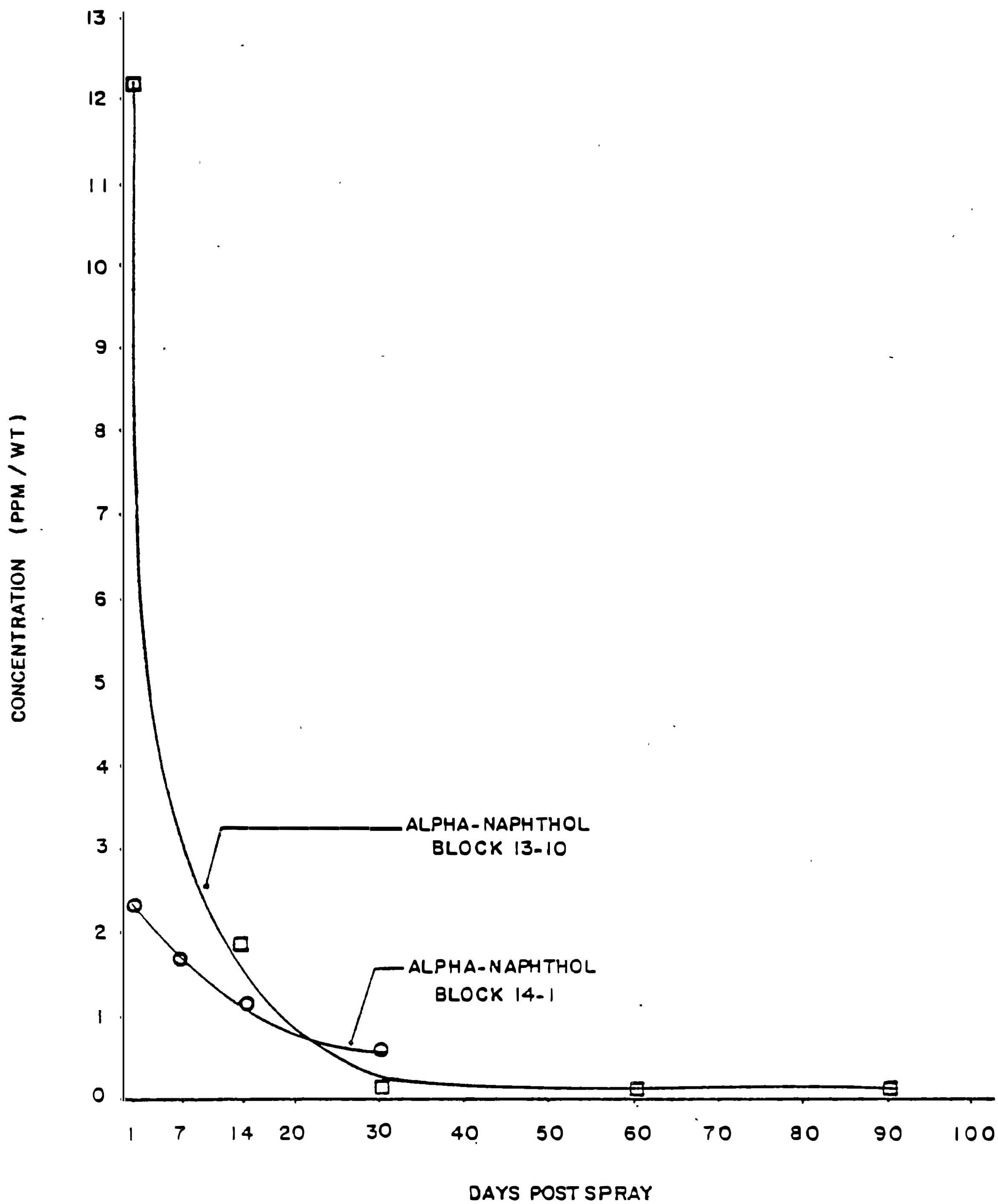


FIGURE 22. ALPHA - NAPHTHOL PERSISTENCE ON FOLIAGE*

* Sevin-4-Oil was not found, its metabolit alpha-naphthol, was found

Litter --

Unlike the foliage samples, the litter samples at all four locations monitored showed the presence of Sevin-4-Oil and alpha-naphthol. The results reported in Table 15 and plotted in Figure 23, where they are shown as concentrations of Sevin-4-Oil, are actually for a combination of Sevin-4-Oil and alpha-naphthol. The analytical procedure used did not differentiate between the two chemicals. The plots of the persistence for blocks 14-1 and 9-8 indicated rapid decomposition, which is expected. Concentrations on litter in block 14-1 decreased by 94.9 percent in 7 days, while block 9-8 showed a decrease of 90.4 percent between 7 and 14 days post-spray.

Plots of persistence for blocks 13-10 and 14-6 did not follow the expected curves. Rather, peak concentrations were observed at 7 days and 14 days post-spray, respectively. The variation from the expected curve may be accounted for by pesticide removal from foliage during rainfall and by the accumulation of pesticide in the litter during runoff and percolation.

DISCUSSION

The results obtained from the monitoring program were influenced in varying degrees by three factors:

- the natural decomposition process
- the amount of rainfall recorded during the sample period
- the variation in <u>actual</u> sample location.

Natural Decomposition Process

The natural decomposition process for these pesticides is fairly rapid, with half-lives varying between 1 to 10 days, depending on the pH, temperature, and moisture content. (Appendix C.)

Rainfall

Rainfall, which occurred in every block during the post-spray period, could have influenced the results in two ways:

- contact with rainfall causes Dylox to enter into solution and run off to other locations,
- falling rain can disperse Sevin-4-Oil.

Depending on the particular location, concentrations of pesticide might have either decreased as the rain removed a part of the pesticide, or increased as the runoff deposited additional pesticide. This action would explain the accelerated decomposition that took place in certain instances, as well as the peaking of concentrations in litter samples at the 7 or 14-day sample periods.

TABLE 15. SEVIN-4-OIL CONCENTRATION RANGE IN LEAF LITTER

Day	Concentration (ppm/wt) Block 14-1	Block 13-10	Block 9-8	Block 14-6
1 (one hour)	17.24	4.4	*	-
7	0.386	13.2	6.73	0.65
14	0.724	0.769	0.648	1.32
30	*	0.636	1.18	0.65
60	*	*	*	*
90	*	*	*	*

- No sample obtained
* Lab analysis negative

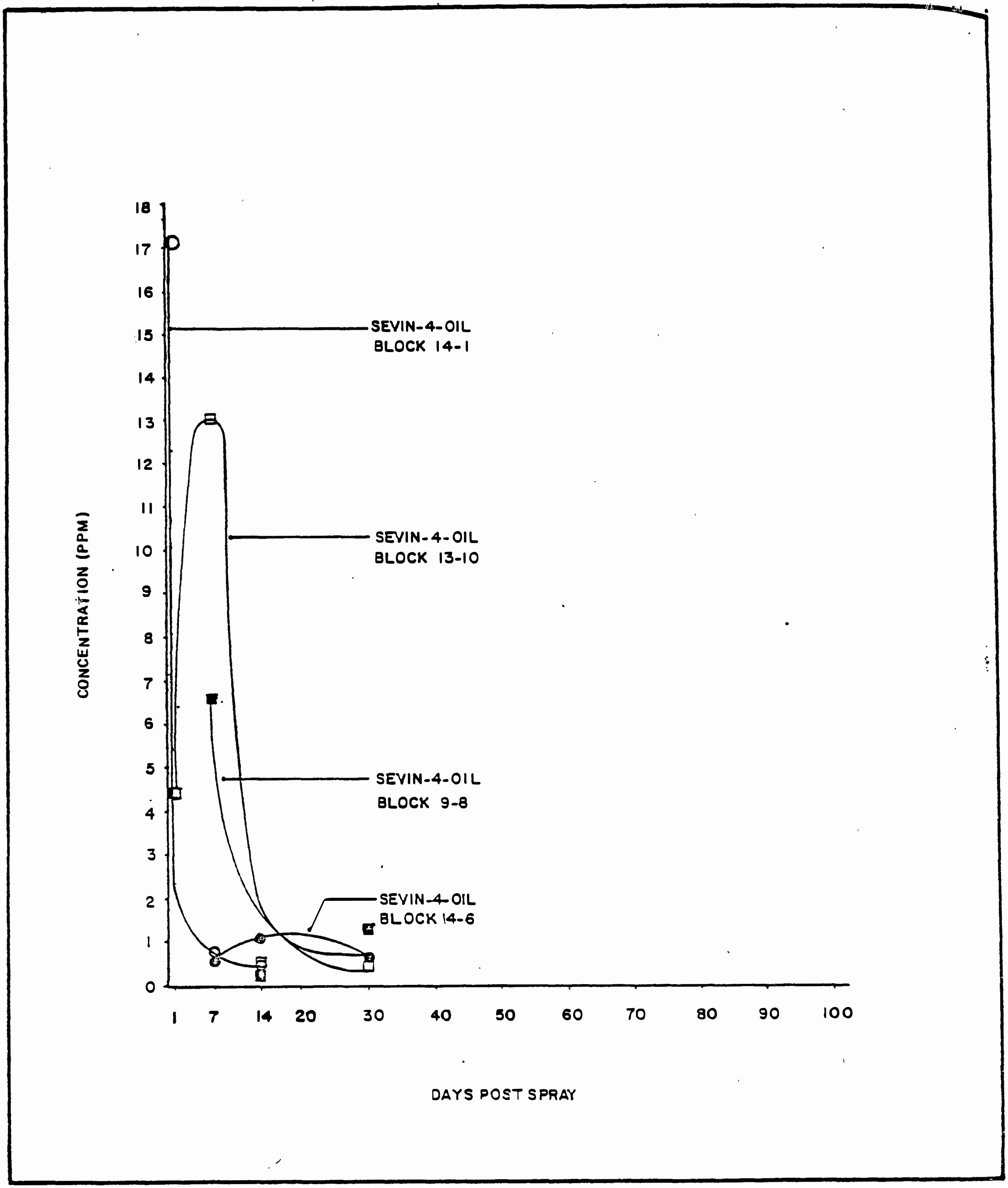


FIGURE 23. SEVIN-4-OIL PERSISTENCE ON LITTER

Sample Location

Although extreme care was taken to obtain samples, it was necessary to remove samples from relatively large (for control purposes) areas. For leaf litter samples, an area measuring approximately 2 feet by 2 feet was needed to obtain each sample. A total area of approximately 24 square feet was necessary to obtain all of the samples. (At the small concentrations encountered, it is possible to experience wide variations.) In addition, the effects of wind direction and flight orientation may cause the actual drip line (Figure 10) to be larger than the area directly under the tree. Foliage "shading" could occur if foliage upwind of the sample site captured the pesticide and prevented it from landing on the leaf litter, downwind of the tree. If litter sampling inadvertantly occurred in a "shaded" area, a variation due to sample location could also occur. Foliage samples consisted of four or five 10-inch-long segments from the tips of branches. Some movement about the tree was necessary to obtain all six of the samples. Again, the area covered by the sampling was large enough to experience the small variations encountered.

CONCLUSION

From the information obtained in the monitoring program, the following conclusions can be made:

- The half-life of Dylox on foliage appeared to be about one day.
- The half-life of Dylox on forest litter was about three days.
- The half-life of Sevin-4-Oil on foliage ranged between three days to ten days.
- The half-life of Sevin-4-Oil on leaf litter could not be determined because of sample variations.
- Rainfall appeared to accelerate decomposition and cause variations in concentrations on leaf litter.

REFERENCES

1. USDA Technical Bulletin 1596, Methods of Sampling and Assessing Deposits of Insecticidal Sprays Released Over Forests. USDA Forest Service, Washington, D.C., 1978.

2. R.K. Dumbauld and J.R. Buorklund, 1977. Deposition Profile Calculations for The State of Maine 1977 Spray Program. H.E. Cramer Company, Inc., Salt Lake City, Utah, 84108.

APPENDIX A

REGRESSION ANALYSES

Conversion of the stain data into droplet sizes was accomplished by using regression analyses for the pesticides monitored on the spray cards.

The regression analyses were prepared in the laboratory using atomizers. Obviously, field conditions will vary slightly. However, the regression analyses used were considered more than adequate.

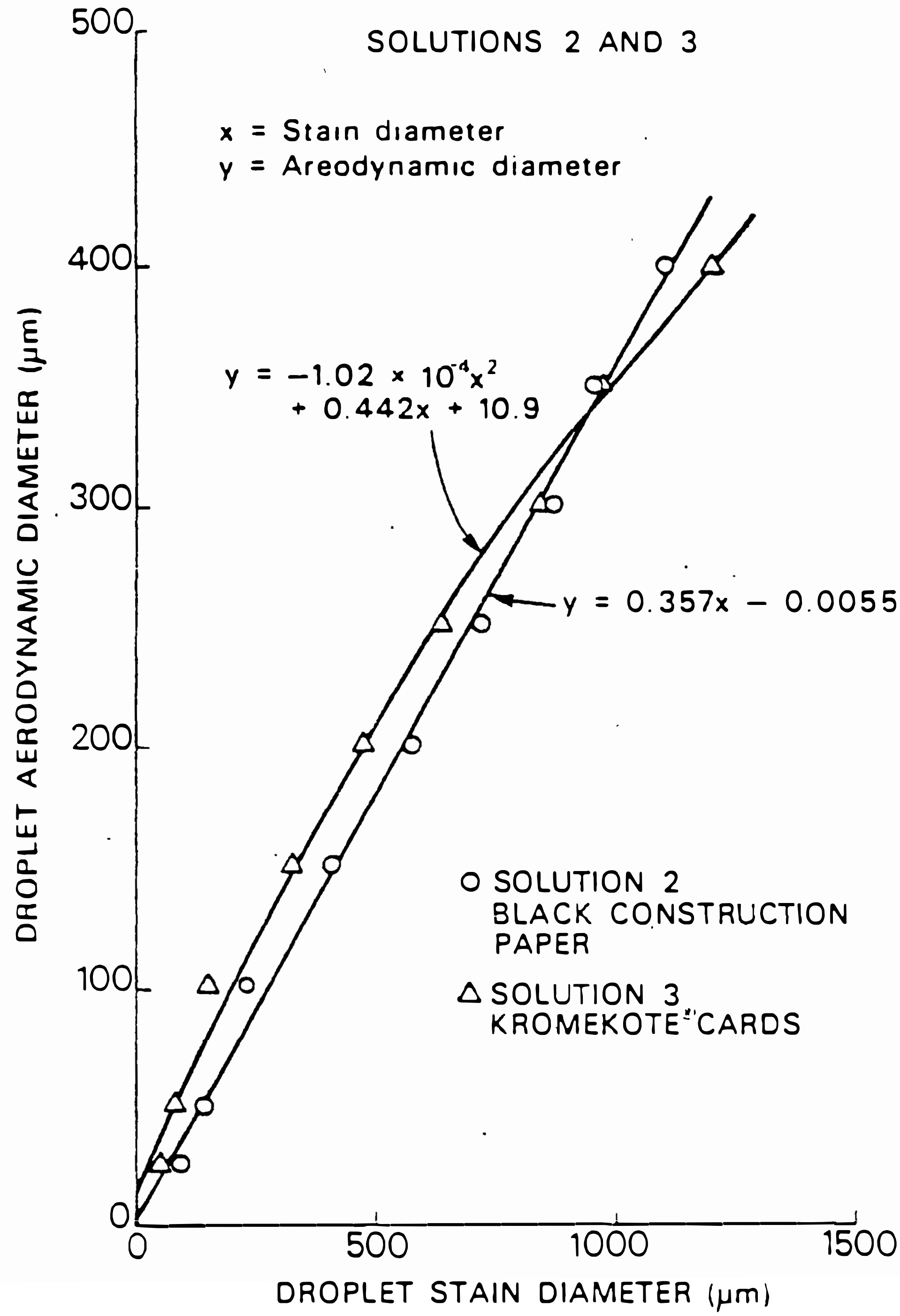


Figure 33.—Spread factor equation for SEVIN 4 Oil on black construction paper and white Kromekote cards.

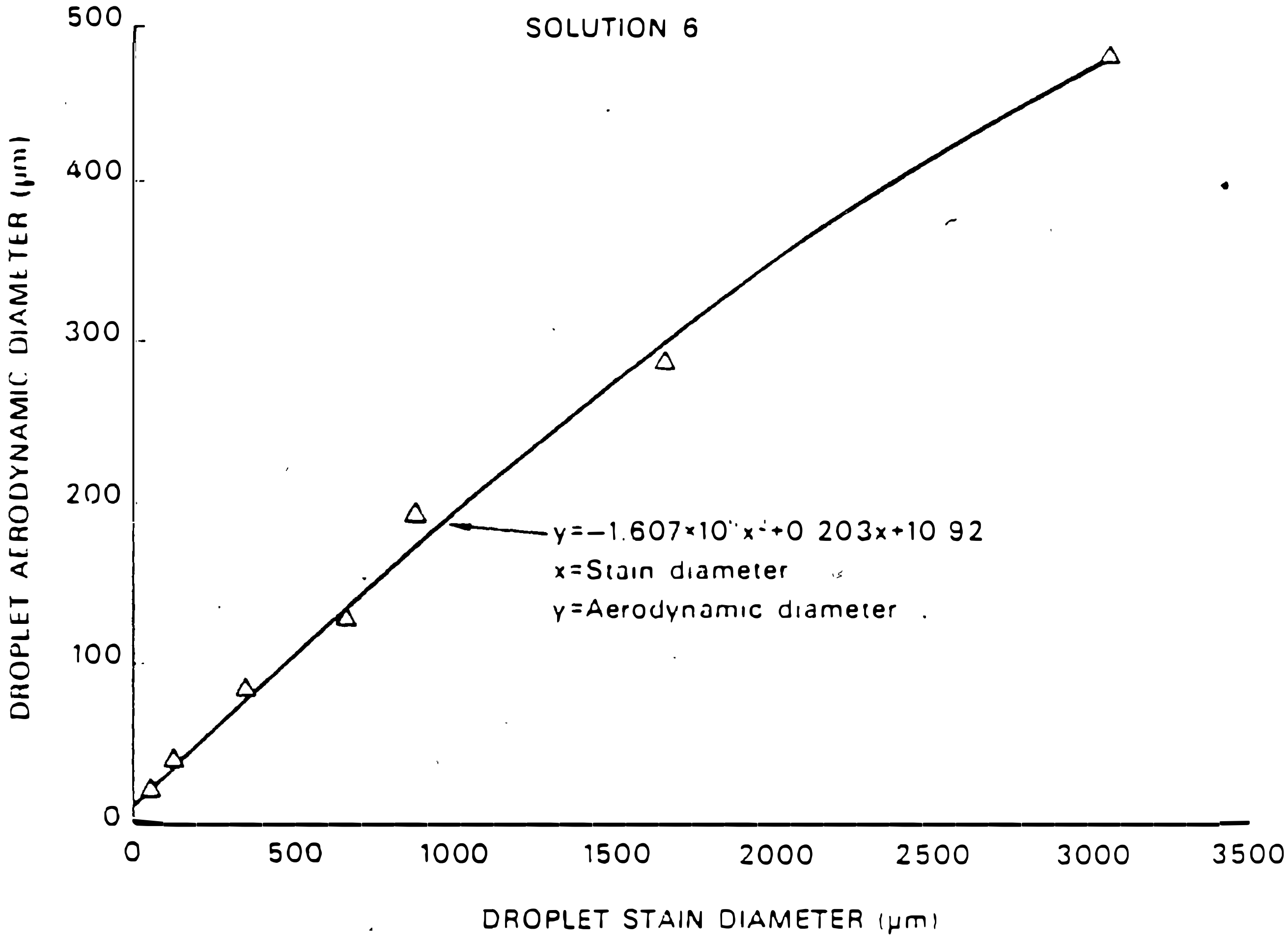


Figure 36.—Spread factor equation for Dylox 4, 24 oz, and HI SOL, 8 oz, on white Kromekote cards.

APPENDIX B

PARTICLE SIZE DISTRIBUTION

TABLE 1. PARTICLE SIZE DISTRIBUTION
NUMBER OF DROPLETS FOR EACH SIZE CATEGORY AND SAMPLE LINE
STATION FOR SAMPLE BLOCK 30-5 LINE A. DYLOX

	Range of Droplet	1	2	3	4	5	6	7	8	9
	Size in μm	0-20	20-33	33-46	46-59	59-72	72-84	84-98	98-109	109+
Sample Line Station	1/8 mile into block	2	59	53	39	20	13	11	17	4
	edge of block	1	5	11	29	9	12	7	6	3
	1/8 mile out-of-block	5	26	38	43	11	1	1	1	3
	1/4	1								
	3/8	0								
	1/2	0					1			
	5/8	0								
	3/4	0								1
	7/8	0								
	1	0								
	1-1/4	0								
	1-1/2	0								
	1-3/4	0								
	2									

TABLE 3. PARTICLE SIZE DISTRIBUTION
NUMBER OF DROPLETS FOR EACH SIZE CATEGORY AND SAMPLE LINE
STATION FOR SAMPLE BLOCK 14-1 LINE C. SEVIN-4-OIL

Sample Line Station	Range of Droplet	1	2	3	4	5	6	7	8	9
	Size in μm	10-39	39-69	69-99	99-130	130-162	162-194	194-228	228-262	262+
	1/8 mile into block	212	5	1						
	edge of block	202	14	11	10	1				
	1/8 mile out-of-block	84	49	15	6	8	4	2		
	1/4	292	48	31	16	4	3	2		
	3/8	11								
	1/2	54								
	5/8	35								
	3/4	32								
	7/8	16								
	1	19								
	1-1/4	-								
	1-1/2	18								
	1-3/4	-								
	2	15								

TABLE 2. PARTICLE SIZE DISTRIBUTION
NUMBER OF DROPLETS FOR EACH SIZE CATEGORY AND SAMPLE LINE
STATION FOR SAMPLE BLOCK 30-5 LINE B. DYLOX

Sample Line Station	Range of Droplet	1	2	3	4	5	6	7	8	9
	Size in μm	0-20	20-33	33-46	46-59	59-72	72-84	84-98	98-109	109+
	1/8 mile into block	1	8	20	29	14	9	3	3	3
	edge of block	6	14	20	12	6	1	0	1	0
	1/8 mile out-of-block	3	9	5						
	1/4	5	5	3	1					
	3/8	1	9	3	1					
	1/2									
	5/8	1	5	2	0	1	1			
	3/4	8	9	10	2					
	7/8	1	5	14	8					
	1									
	1-1/4									
	1-1/2									
	1-3/4									
	2									

TABLE 3. PARTICLE SIZE DISTRIBUTION
NUMBER OF DROPLETS FOR EACH SIZE CATEGORY AND SAMPLE LINE
STATION FOR SAMPLE BLOCK 14-1 LINE C. SEVIN-4-OIL

Sample Line Station / Range of Droplet	1	2	3	4	5	6	7	8	9
Size in μm	10-39	39-69	69-99	99-130	130-162	162-194	194-228	228-262	262+
1/8 mile into block	212	5	1						
edge of block	202	14	11	10	1				
1/8 mile out-of-block	84	49	15	6	8	4	2		
1/4	292	48	31	16	4	3	2		
3/8	11								
1/2	54								
5/8	35								
3/4	32								
7/8	16								
1	19								
1-1/4	-								
1-1/2	18								
1-3/4	-								
2	15								

TABLE 4. PARTICLE SIZE DISTRIBUTION
NUMBER OF DROPLETS FOR EACH SIZE CATEGORY AND SAMPLE LINE
STATION FOR SAMPLE BLOCK 13-10 LINE E. SEVIN-4-OIL

	Range of Droplet	1	2	3	4	5	6	7	8	9
	Size in μm	10-39	39-69	69-99	99-130	130-162	162-194	194-228	228-262	262+
Sample Line Station	1/8 mile into block	247	45	25	8	4	2	1		
	edge of block	101								
	1/8 mile out-of-block	127	5							
	1/4	98	5							
	3/8	37	1							
	1/2	63								
	5/8	12								
	3/4	0								
	7/8	-								
	1	-								
	1-1/4	-								
	1-1/2	-								
	1-3/4	-								
	2	-								

TABLE 5. PARTICLE SIZE DISTRIBUTION
NUMBER OF DROPLETS FOR EACH SIZE CATEGORY AND SAMPLE LINE
STATION FOR SAMPLE BLOCK 9-8 LINE F. SEVIN-4-OIL

	Range of Droplet	1	2	3	4	5	6	7	8	9
	Size in μm	10-39	39-69	69-99	99-130	130-162	162-194	194-228	228-262	262+
Sample Line Station	1/8 mile into block	329	59	31	34	24	19	7	2	2
	edge of block	89	35	11	2	1	1			
	1/8 mile out-of-block									
	1/4	0								
	3/8									
	1/2	7								
	5/8									
	3/4	9								
	7/8									
	1	7								
	1-1/4									
	1-1/2	6								
	1-3/4									
	2	8								

TABLE 6. PARTICLE SIZE DISTRIBUTION
NUMBER OF DROPLETS FOR EACH SIZE CATEGORY AND SAMPLE LINE
STATION FOR SAMPLE BLOCK 14-6 LINE G. SEVIN-4-OIL

	Range of Droplet Size in μm	1 10-39	2 39-69	3 69-99	4 99-130	5 130-162	6 162-194	7 194-228	8 228-262	9 262+
Sample Line Station	1/8 mile into block	123	9	11	6	2				
	edge of block	43	4	1						
	1/8 mile out-of-block									
	1/4	43	3	1						
	3/8									
	1/2	35	1	1						
	5/8	48	6							
	3/4									
	7/8									
	1									
	1-1/4									
	1-1/2	40	5							
	1-3/4									
	2	23								

APPENDIX C

PESTICIDE DECOMPOSITION

PESTICIDE DECOMPOSITION

Sevin-4-Oil, Dylox and Orthene were monitored to determine their presence and persistence in spray block streams and stream sediments. A review of literature concerning these pesticides indicated the behavior in aquatic states is highly variable and dependent on such factors as:

- pH
- temperature
- time

Dylox

Dylox is a water-soluble, phosphorus-based pesticide. In its parent state, it is a dimethyl phosphonate. The decomposition of the chemical is brought about by the processes of dealkylation and hydrolysis. Breakdown products include dimethyl phosphate, monomethyl phosphate and inorganic phosphates. The half life varies significantly but:

- decreases as temperature increases,
- decreases as pH increases, and
- decreases as moisture increases.

Sevin-4-Oil

Sevin-4-Oil is a slightly water-soluble carbamate insecticide. The parent material (1 naphthyl-N methyl carbamate) is decomposed by hydrolysis and metabolic process of micro-flora and micro-fauna. The first by-product is alpha-naphthol. The half life can vary from 1 to 10 days. The decomposition is dependent on pH and temperature in the same manner as Dylox.

Orthene

Orthene is a water-soluble systemic, organic phosphate insecticide. The parent material (O,S - Dimethyl acetylphosphoramidothioate) is broken down to monitor and innocuous salts by hydrolysis and metabolic process of micro-flora and micro-fauna. Activity of the pesticide is limited to 5 to 10 days. The decomposition is dependent on pH, temperature, and moisture in the same manner as Dylox and Sevin-4-Oil.

Stearns (SCS)

DANIEL T. JENNINGS

Environmental Monitoring of the 1979 Budworm Suppression Project

by SCS Engineers

June 4, 1980

SCS ENGINEERS
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CELEBRATING OUR 10 ANNIVERSARY
QUALITY ENVIRONMENTAL SERVICES
1970-1980

June 4, 1980
File No. A0679

Mr. Temple Bowen
Forest Insect Manager
Maine Bureau of Forestry
Ray Building
Augusta, Maine 04333

Dear Mr. Bowen:

We are pleased to submit five (5) copies of the "Final Report - Environmental Monitoring of the 1979 Budworm Suppression Project" in accordance with our contract dated July 25, 1979. Please note that we have previously submitted four draft reports concerning: 1) field monitoring procedures; 2) results of airborne drift monitoring; 3) results of waterborne drift monitoring; and 4) results of monitoring pesticide residue and persistence on foliage and leaf litter. Following each submission, we have met with Forestry staff to review findings, format and discussions.

The results obtained in this monitoring effort are an important step in narrowing the data gaps which exist. Hopefully, future monitoring efforts will further close the data gaps and enable decisions and policies to be made, based on fact and sound judgement.

We have enjoyed working with you and your staff on this project and look forward to future opportunities to work together.

Sincerely,

Ronald A. Perkins, P.E.
Vice President
SCS ENGINEERS

RAP:llc

Enclosures